POWER and THE ENGINEER
EVERYTHING ABOUT THE GENERATION AND TRANSMISSION OF POWER

Vol. 32 NEW YORK, FEBRUARY 1, 1910 No. 5

An Indicator That Made More Than A Diagram

Not long ago there were a dozen or more applications for the job of chief engineer of a big office building right in this man's town.

The owners, having sifted the number of applicants down to seven, did not know how to choose between them.

They called in the consulting engineer who laid out and erected the power plant. He glanced over the seven applications for a few minutes and then drew out a letter.

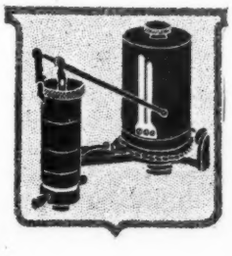
"There's your man," said he.

A little curious to know why and how he chose one name from the seven when all appeared to be equally good, the "Old Man" of the concern asked why this man was chosen, and received the following reply:

"That man says, 'I own my own indicator and know how to use it.' Now, a man that knows how to use an indicator and read diagrams must know the other parts of his business as well."

"Yes," said the Old Man, "I see your point, and it is well taken, but these indicators are cheap—anyone could buy one."

"Cheap enough to you, sir," said the consulting engineer, "but expensive luxuries to working engineers, with their small pay.



"Why, sir," he proceeded, "an engineer who has pride enough in his business to skimp out of his wages enough money to buy an indicator, and then takes time to use it, and study the story it tells, is worth twice as much to you or any other employer as a 'don't-give-a-damn' engineer who stops and starts your machinery.

"Some good men cannot afford an indicator, I say it to the shame of their employers. But any engineer that buys one deserves a raise of pay—and such a raise would be the best investment his employer could make."

The consulting engineer was now getting "warmed up." "Why don't employers appreciate the men who work for them—body, soul and breeches—these same engineers?

"Here you howl about the unions forcing you to pay high wages, and maybe they do, but here's a class of men without a union, who are supporting a great educational association to discover ways to do your work better and cheaper, and buying indicators to save the firm's money.

"Where is the fairness of these employers? Why don't they raise the pay of their engineers so that they will at least rank with foremen? If they start a union, 'bet your life' it will go higher than that.

"But, you bet on your indicator-owning engineer—he belongs to the aristocracy!"

Power Plant Signaling System

Novel Signaling System between Switchboard Operator and Engineer of Plant, Consisting of Whistle, Illuminated Signal Board and Order Panel

BY WARREN O. ROGERS

In large power plants it is absolutely necessary that some method of signaling between the switchboard and engine-room attendants be established. A complicated arrangement of signals is not advisable, but a quick method of communication is essential.

A most successful homemade signal system for power-plant purposes may be found in the Marion power station, of the Public Service Corporation of New Jersey. By means of this system of signaling, the switchboard operator can communicate to the firemen in the boiler room, with the men on the turbine floor, and they with the switchboard operator.

In Fig. 1 is shown the order panel, on top of which are placed the necessary switches, and signal-indicating pointers for the use of the switchboard operator. In each of the three boiler rooms, at one end, and in a position that the men can see, is a signal panel, shown in Fig. 2. This panel is so designed that the approximate load on the combined turbine units is shown in figures indicating the total kilowatts on the switchboard panel. The firemen have, therefore, ample opportunity to regulate their fires and steam pressure to carry the existing loads and to take care of any additional load that may be expected.

Order Board

The method of operation is simple. On the top of the order board are the necessary switches and indicator arms. Referring to Fig. 3 it will be seen that the two center switches on the upper edge of the board are designated as "0 0" and "0." At each side of the order contacts are placed two brass plates having ten indicating points numbered from 1 to 9, the tenth being the off point. The plate at the right indicates thousands, that at the left, ten thousands. Pins suitably spaced are fitted to a cylinder, one for each indicating plate, which is suspended in suitable bearing under the board. These pins make contact with nine different circuits running to the signal board in the boiler room, which connects with as many different sets of lamps placed behind the glass face of the boiler-room signal board.

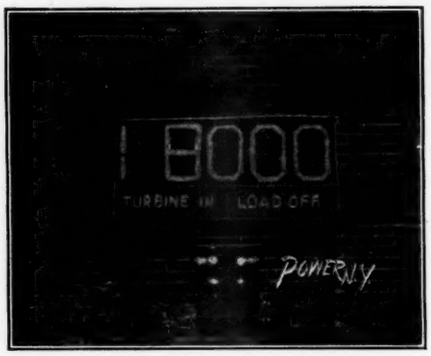


Fig. 2. Boiler-room Signal Panel

Boiler-room Signal Board

The boiler-room signal is composed of a box having five sections, each partitioned off into seven compartments, as shown in Fig. 4. In each compartment is placed an incandescent lamp, as shown, connected to the wire leading to the contact springs making connections with the pin in the cylinder under the signal board in the switchboard room. One general return line is used for all lamps, but each combination of lamps is connected to a separate wire connecting with its particular contact spring.

Over the face of the signal board a painted glass face is placed, the black-painted portion showing as indicated in Fig. 5.

With this glass in place, and all the lamps in the boxes lit, the sign will read 88,888, and by extinguishing certain lamps, any combination of figures can be made. For instance, if 18,000 kilowatts is the load on the switchboard, the handle on the indicator plate *A* is set at 1, the handle on plate *B* is set at 8, and the switches marked "0 0" and "0" both thrown in. This will put in circuit four lines of wire running to the signal board, the first having the lamps arranged in circles so that they will flash the figure 1 through the painted glass. The indicator when pointing to the figure 8 puts in circuit the line connecting with the seven sections of the box, and as all seven lamps are connected to this wire, all will burn, forming the figure 8. The switch "0 0" throws the wire connecting to the third and fourth sections of the box into circuit and carries twelve lamps, six in each section, thus showing the figure "0 0" through the glass, the center lamp being out of circuit in each instance and indicated by the dark disk. The switch "0" controls the last section, which also shows the figure "0" through the glass, the entire reading being 18,000 kilowatts, as shown in Fig. 2. By wiring the various lamps to different circuits,

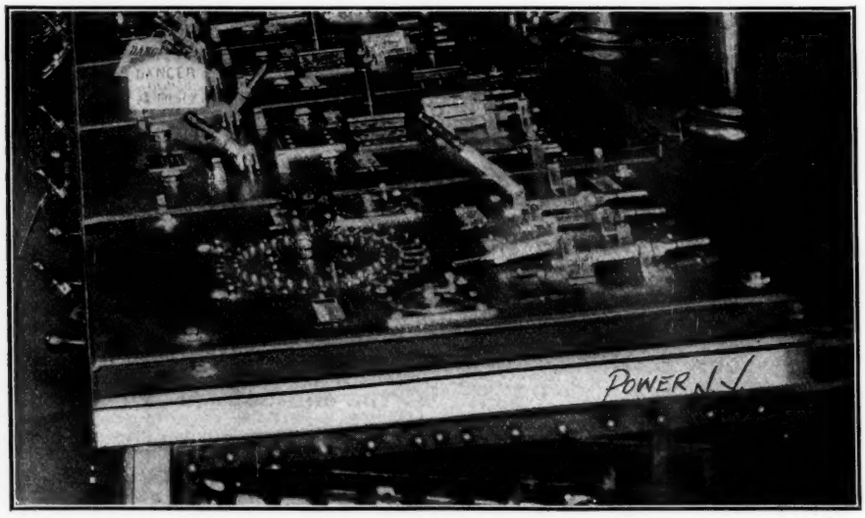


Fig. 1. Order Panel in Foreground

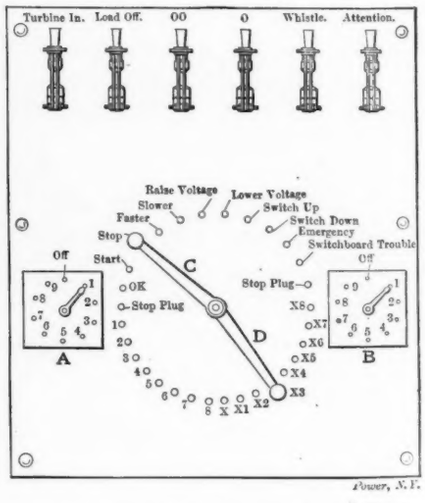


Fig. 3. Diagram of Top of Order Board

any combination of figures can be obtained.

Below the figure portion of the board is a sign which reads "Turbine In" and "Load Off." The letters showing through the glass, are formed by a painted surface, which, with lamps behind, forms the letters, the circuits in each case running to their respective switches on the signal panel in the switchboard room.

Alarm Signals for Turbines

An entirely different signal system is arranged for notifying the chief engineer, or others whose business it is to know, that something is wrong with any piece of apparatus in the turbine or oil-pump room. On the wall, at the back of each turbine, also on the gallery platform of each turbine, at a convenient point, is placed a small signal-alarm box, similar to those used in factory fire-alarm systems, each box blowing its number twice. For instance, No. 1 turbine box blows one blast of the danger-alarm whistle twice, No. 2 turbine blows two blasts twice, No. 3 turbine blows three blasts, twice, and so on for each turbine number.

If anyone is passing any turbine or auxiliary in the plant and notices something not operating as it should, the emergency signal is sounded from the box belonging to that turbine where the trouble is, and the sender of the alarm goes on his way, leaving the proper attendant to take care of his own trouble. As this emergency whistle is of different pitch from the regular working whistle used to call attention to the signal board, there can be no mistaking it, and its first blast is a note of warning.

Midway of the turbine room, and suspended at a hight about level to the top of the largest turbine unit, is an illuminated signal board, shown in Fig. 6.

Across the top of the board is the word "Attention" and the letters O. K. When the switchboard operator desires to change, say exciters, the pointer on the signal panel is turned until it points to the contact that will bring in circuit the lamp which will illuminate the words on the switchboard, the switch operating the magnet controlling the whistle valve is then thrown, thus blowing the whistle to call the attention of the men on the turbine floor to the signal board. By this time the switchboard operator has thrown his signal lever on the switchboard to the word "Start," and "X 4," the latter designating exciter No. 4. When this signal has been obeyed, the load must be taken from exciters Nos. 1 and 2, No. 4 being double the capacity of both. The signal "Attention" is then flashed from the board, the signal whistle blown, and the board made to say "Stop" "X 1-X 2," the latter referring to exciters Nos. 1 and 2, also the signal, "Switch up," is shown, indicating that the exciters may be shut down. Fig. 6 shows to what extent this application of signals may be carried.

The design of the apparatus is similar to that used for signals in the boiler room. In the center of the signal panel three sets of contacts are placed, extending up above the surface of the board. Under the panels are two cylinders connected to the levers *C* and *D*, Fig. 3. In these cylinders are contact pins which, when in the proper position, make contact with their predetermined spring connections. At designated points, the same words, characters and figures will be found as shown on the signal board in the turbine room, Fig. 6. By moving the lever *C* to the contact marked "Stop," contact is made, with a spring contact connection to the circuit lighting the lamps back of the glass face on the board showing the word "Stop," through the clear glass, the surrounding surfaces being painted black. The same process is repeated to light the lamps back of any set of words or figures, the lever being moved to the contact marked with the desired signal word. The lever *D* controls the figures on either outside edge of the signal board, figures 1, 2, 3, etc., designating the turbine number; X1, X2, etc., the exciters.

The switch governing the air for blowing the whistle operates a set of magnets. When the current is thrown on, the armature of the magnet is drawn up, which, being attached to the lever operating the valve, allows air to pass to the whistle. The arrangement is shown in Fig. 7. The whistle, magnets, etc., are shown on the wall in Fig. 6.

Rules Governing Signaling

The following rules have been arranged for the use of engineers and operators when cutting in or out machines:

Cutting in Machine; Operator to Engineer

In using the signal panel to indicate

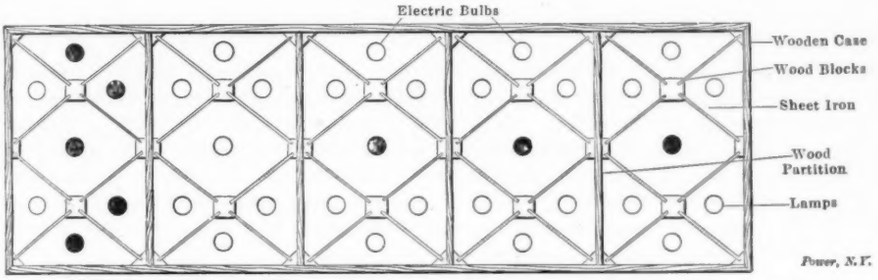


Fig. 4. Showing Boxes, Partitions and Lamps

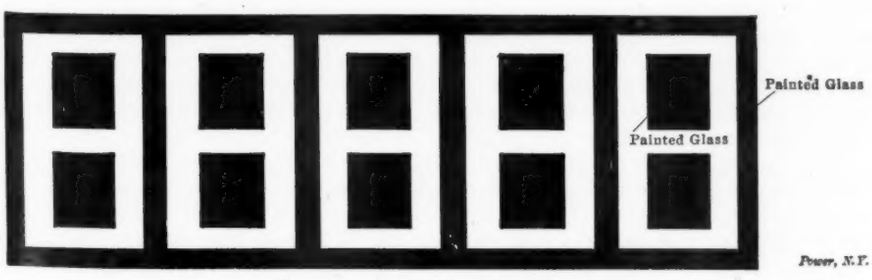


Fig. 5. Painted-glass Face

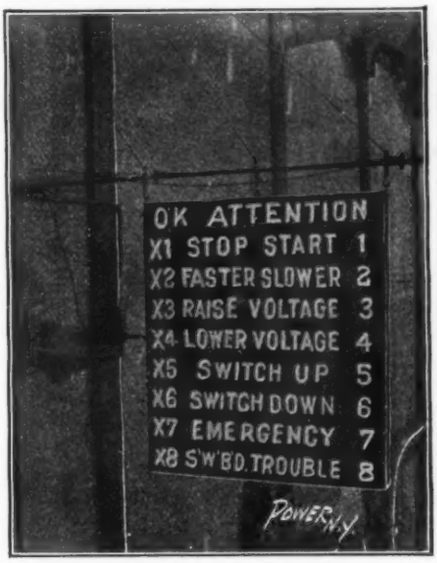


Fig. 6. Signal Board

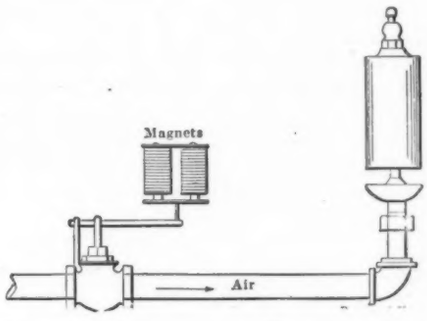


Fig. 7. Magnets and Whistle Valve

need to start machines, the operator, after each answering bell from the engineer must signal O. K. on the signal panel. The signal panel must be used at all times to communicate with the engine room.

ENGINEER TO OPERATOR

One bell for field current.
Two bells to cut in machines.
Three bells for load.

The engineer will be governed by the signal panel as to conditions of the switchboard.

CUTTING OUT MACHINES; OPERATOR TO ENGINEER

Use signal panels to indicate that conditions of board are such as to necessitate cutting machine out. The operator must then await answering bell signals from the engineer, governing himself by them. The operator after each bell signal from the engineer must flash the O. K. signal on the board.

ENGINEER TO OPERATOR

Three bells indicates readiness.
Two bells, cut the machine out.
One bell, cut out fields.

Engineers will be governed by the signal panel as to the conditions of the switchboard. Operators on noting any trouble whatsoever on the switchboard must give three or four short blasts of the air whistle to notify the engineers.

A small whistle is also used for the purpose of calling the attention of the men on the floor that a telephone call is waiting. The whistles will blow until the receiver has been taken down. All whistles are blown by compressed air.

Laying Up and Inspecting Boilers

If it is intended not to use a boiler for some time, it should be emptied of its water and thoroughly dried out. If the air is so moist that the inside of the boiler is not dried by the air circulation, a pan of charcoal may be lighted and set inside the shell for a few minutes. When this is removed, it is well as an extra precaution to place a box or pan of quicklime inside the boiler before closing it up. If this is done, however, the box should be so constructed that the lime cannot come into contact with any of the metal parts, or corrosion may result. After making sure that the inside of the boiler is dry and will remain so, the boiler should be closed up and the exterior given a good coat of linseed oil. These precautions will prevent largely the oxidation of the metal. All fittings should be well painted.

If for any reason the foregoing plan of laying up the boiler is impracticable, the boiler should be filled quite full of water. To this should be added soda ash or common soda in the proportion of 50 pounds to 100 cubic feet of water. The air should then be boiled off and the boiler closed up tight. Whether the method of laying up set forth in this paragraph or the preceding paragraph is adopted, the boiler should be thoroughly cleaned before starting it up again.

In laying up, the furnace, combustion chamber, tube ends, etc., should be thoroughly cleaned of soot, to prevent corrosion.

Boilers that are used only part of the time, should, after being cleaned, be filled full of water.

A boiler out of use, if not properly cared for, will deterioriate much faster than a boiler in use.

PRECAUTIONS IN ENTERING A BOILER

Never get into a boiler without mentioning the fact to other persons about the power plant. Be sure the blowoff cock is closed, to avoid sewer gas, or scalding water from another boiler. It is an excellent plan to lock shut the valves on the boiler steam, feed and blowoff pipes during cleaning and inspection, to prevent accidental opening of them while someone is inside the boiler.

It is dangerous to take off the manhole cover before all the pressure has had time to die down. Pressure gages often show zero pressure when there is still some two or three pounds pressure in the boiler. A pressure of only two pounds on every square inch of a manhole cover is quite sufficient to blow it off with violence and severely injure those in the act of taking off the cover. Many serious accidents have occurred in this way. To avoid such accidents and to make sure there is no steam pressure left in the boiler after the water has been blown out, it is a wise precaution before taking off any covers to lift the safety valve or open the water-column connections.

After opening the manholes and the handholes, close all doors and open the damper. This will produce a current of air through the boiler and up the chimney. It is particularly important to do this on opening up a boiler in which kerosene has been used, or to which other oil, or sewer gas, may have gained admission. Be careful also not to have any lights in or near the boiler until it has been thoroughly aired out. If any inflammable vapor is present, it may ignite and cause serious personal injuries.

Never enter a boiler with a naked light, such as a candle, lamp, lighted match, etc., without first holding the light down in the boiler at arm's length, or preferably suspended on a stick. If the boiler contains an inflammable mixture, due to oil or sewer gas, the explosion will then take place before the man enters. Many serious, and several fatal, explosions have occurred from neglect of this simple precaution. It is well to use a portable electric handlamp.

Before entering the combustion chamber, the ashes should be hoed out of it. Some attendants, instead of taking them out, make a practice of wetting them down with a hose. This not only damages the setting walls, but also leaves the combustion chamber in a dangerous condition to be entered. Many a serious burn has been received by crawling into a combustion chamber which has been treated in this way, and sinking through a cold crust of six or more inches into red-hot ashes. Heat may be retained beneath ashes in this manner for several days.

INTERNAL INSPECTIONS

Each time the boiler is put out of service a thorough internal inspection should be made. This is the only certain method of knowing the condition of the boiler and is the best safeguard against accident.

Examine all stays and see that they are taut and in good order. Look for pitting around any drum connections and for grooving in the side seams. Examine carefully all outlets and pipe connections, as they are specially liable to corrosion. Clean and wash pipe connections to water column every time the boiler is cleaned. Careful attention should also be given to the seams to make sure that no cracks have developed. If the existence of a hidden crack is suspected, and hidden cracks, as has been already noted, are particularly liable to develop in the longitudinal seams, the rivets should be cut out and the plates separated for examination.

Mud drums should be given careful attention and cleaned and inspected regularly just the same as the boiler. Blowoff valves and piping, especially nipples to the mud drums of water-tube boilers, should be sounded with a hammer at each cleaning.

In locomotive and vertical boilers, clean and wash out the water legs frequently.

Just as soon as the manhole cover has been fastened in its place, turn on the feed until two gages of water are gotten. Fires have been built under empty boilers due to forgetting to turn on the feed, and costly repairs thereby made necessary.—*The Fidelity and Casualty Company of New York.*

Mixed Pressure Turbine and Engine Plants

Possibilities of This Combination for Manufacturing Plants of Moderate Size where the Load Is Variable and There Is Frequent Demand for Exhaust Steam

BY H. Y. HADEN *

The subject of the low-pressure turbine has recently been given considerable discussion and several authentic tests showing the results obtained from the combination of some large-sized cross-compound engines exhausting at approximately atmospheric pressure into low-pressure turbines have demonstrated a superior economy in steam consumption per total horsepower than can be obtained from the reciprocating engine or from the turbine operating alone under the most favorable steam conditions for each unit; and it has already been pointed out the reason for this lies in the ability of the turbine to take out a greater percentage of the energy present in the steam at the lower pressures and temperatures so that a greater horsepower output can be developed from a given weight of steam in the later stages of expansion. This result, combined with the undoubted greater efficiency of the reciprocating engine in the earlier stages of expansion, would naturally bring about the ideal condition in the proper combination of the two units.

In all installations of the above kind on which data have been obtained, the turbine has been of the simple low-pressure type; that is to say, the load which the turbine unit would carry was dependent entirely on the exhaust steam available from the engine and consequently on the engine load and it was not even found necessary to put a speed governor on the low-pressure turbine but simply tie the turbine generator in electrically with the engine generator and let the load divide itself between the two units.

The purpose of this article is to show the possibilities of the independent mixed-pressure turbine combined with the reciprocating engine as an economical power producer in manufacturing plants of moderate size where considerable elasticity is required, due to a variable power factor, and where from time to time supplies of exhaust steam of low-pressure steam are desired for heating or manufacturing purposes. The example which the writer proposes to take will be a moderate-sized manufacturing plant where approximately 500 to 800 horsepower constitutes the normal load condition. The numbers of such plants are of course legion and it will be readily admitted that there are many manufacturers who would gladly welcome an arrangement of power units whereby they can retain the original engines and at the same time reduce the coal consumption per annum.

*President of the Turbine Equipment Company, New York City.

Before discussing the possibilities of the results to be obtained in the type of plants referred to, it would be well to give a description of the mixed-pressure turbine which would form the basis of these economies. The mixed-pressure turbine is a further development of the low-pressure turbine and the essential difference between the two types of units is that the mixed-pressure turbine becomes an entirely independent machine operated by its own governors, but one that will be capable of utilizing all the available exhaust steam from the engines operating in connection. It has been found that in certain types of turbines where steam nozzles or jets are used, the turbine-wheel case can be so arranged as to allow the use of two complete sets of steam nozzles, each set designed to allow of the proper number of expansions of the steam under each condition to the desired final pressure, thereby enabling the maximum of economy to be developed under each condition. In this way it is possible to build a combination turbine that will take high- or low-pressure steam, or both, depending on the amount of exhaust steam available, the changes in these conditions of operation being brought about automatically.

It is therefore proposed to discuss the installation of this type of unit together with a simple Corliss engine of approximately 33 per cent. greater horsepower capacity than that of the low-pressure turbine, and to show by means of performance curves that the results obtained should show a superior inherent economy to that obtained from a highly efficient cross-compound condensing engine having the capacity of the two combined units; moreover, that the engine and turbine could be connected together so as to furnish at any time a supply of exhaust steam under approximately one or two pounds pressure above atmosphere, which could be used for either heating or manufacturing purposes, and this, without reducing in any way the capacity of the combined units and with but a small increase in the fuel consumption. A further source of economy in such an installation would be the possibility of using the surplus exhaust from auxiliaries operating in the engine room. There are many plants where steam-driven air compressors are installed operating noncondensing, and these could be transformed into highly economical machines by connecting the exhaust into a receiver between the engine and turbine. A further advantage that will be noted immediately from the curves to be shown later is the comparatively high economy that could be obtained from a plant of this kind with a very low load factor, as the engine could be shut down and the turbine operated as a straight high-pressure condensing unit and would give a load as low as 25 per cent. of the total output of the plant with but a slight decrease in economy from that obtained at the best point on the combined curve. This is a result that could not be obtained from any engine operating under the most advantageous steam conditions. It will also be shown that the first cost of such an installation including generators, condenser, foundations, etc., should not exceed the total first cost of a high-grade cross-compound engine generator set with its condenser; also, that the plant efficiency should be maintained more evenly in the case of the combined units than with the single large unit, as will be shown later.

The example to be taken will be a 450-kilowatt combined unit to be installed in a manufacturing plant where condensing water is available and where the other conditions above noted will be present. The units would consist of a 250-kilowatt simple Corliss engine or a four-valve engine and a 200-kilowatt mixed-pressure turbine capable of developing the full output either from exhaust steam at approximately atmospheric pressure or from high-pressure steam at boiler pressure, Fig. 1 showing a diagrammatic arrangement of the two units in relation to their supplies of high- and low-pressure steam. It might be stated here that it is taken for granted in any of these installations that the proper heating of the feed water is taken care of either from the exhaust of the boiler-feed pump or other auxiliaries in the boiler room. Also the condensing system has not been shown because there would be no departure from the regular practice and it would depend entirely on existing conditions whether a barometric or surface type condenser were used. In any case, however, the condensing installation should be such that an average of 27 inches of vacuum could be maintained throughout the year. Fig. 2 shows the curves of performance of the combined 250-kilowatt engine and 200-kilowatt turbine units, curves being plotted on the actual performances of this type of engine and from the guarantees made by a reputable turbine manufacturer. Curve *A* shows the steam consumption per kilowatt at the switchboard that would be obtained from a high-class com-

pound Corliss engine having a capacity of 450 kilowatts at the best point. This engine would operate at about 100 revolutions per minute with a mechanical efficiency of about 94 per cent. and a generator efficiency at full load of 92½, the efficiency falling on half load to 91 per cent. Curve *B* shows the performance of a four-valve 250-kilowatt engine operating noncondensing and exhausting to a back pressure of approximately one pound above atmosphere. This engine would operate at about 200 revolutions per minute with a mechanical efficiency of approximately 94 per cent. and would have the same generator efficiency as the 100 revolutions per minute 450-kilowatt generator at full load, but the efficiency at half load would drop to 90 per cent. Curve *C* shows the guaranteed economies of a low-pressure 200-kilowatt turbine taking steam at one pound pressure above atmosphere and exhausting to a final pressure of 1½ pounds absolute. This curve, as before stated, is plotted from a manufacturer's guarantee. Curve *D* shows the combined results of the simple engine and low-pressure turbine where all the exhaust steam, less that lost from condensation, is available for the turbine unit and where it is not necessary to introduce any live steam to the turbine to make up a deficiency of exhaust steam. The loss due to condensation probably would not exceed 13 per cent. where a short and properly lagged exhaust line is used between engine and turbine inlet. Curve *E* shows a performance curve of the turbine unit operating entirely from high-pressure steam and condensing to 1½ pounds absolute. Curve *F* shows the performance of the combined units where 2000 pounds per hour of exhaust steam at one pound pressure is withdrawn from the engine exhaust for the purpose of heating or manufacturing; in other words, in plotting this curve, the engine and turbine has been charged with all of the steam taken from the boilers, notwithstanding the fact that 2000 pounds of this has been diverted for heating or manufacturing purposes, and the turbine deprived of its use. The balance of extra steam required to make up the loss of this 2000 pounds of exhaust steam would of course be drawn from the high-pressure line through the turbine.

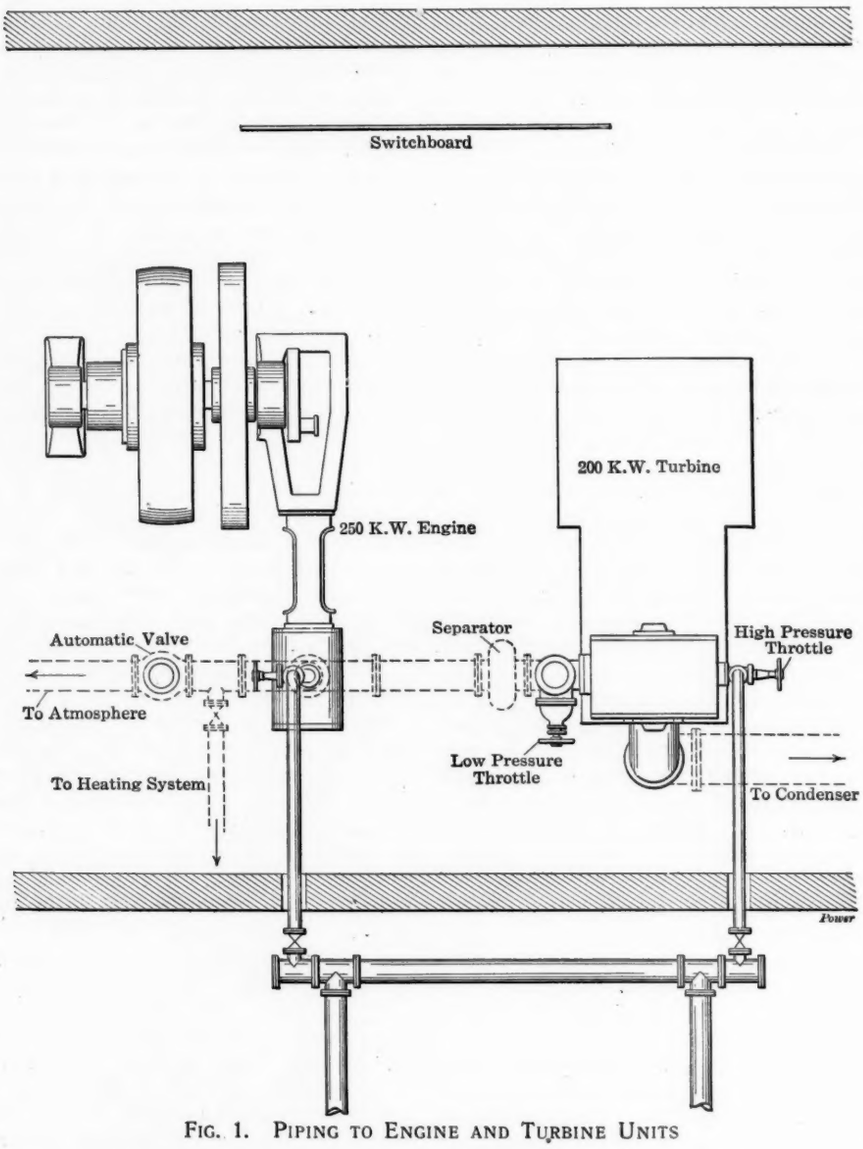


FIG. 1. PIPING TO ENGINE AND TURBINE UNITS

Curve *G* shows the resultant inherent economy of the compound-condensing engine if 2000 pounds per hour of low-pressure steam be taken either from a low-pressure boiler or through a reducing valve from a high-pressure boiler, but this steam charged against the economy of the engine.

In order to simplify the results as much as possible, it is proposed not to include in the economies shown, the steam taken for either the boiler-feed pumps or for the vacuum pump if one is used. This amount of steam would be almost identically the same whether a cross-compound condensing engine were installed, or the plant under discussion, so that the reduction in economies would be equal in both instances. The horsepower required for the circulating pump which is to give a ratio of 50 to 1 of condensing water through a total head of 40 feet has, however, been deducted from the economy of the turbine. This horsepower has been calculated, based on a motor-driven centrifugal pump operating from the turbine generator and having a combined efficiency of 60 per cent., and it is seen that this is but 2.3 per cent. of the total horsepower output at full load. This percentage has therefore been charged against curve *D*. In the case of the cross-compound engine performance the ratio of circulating water has been taken at 33 to 1 on account of the lower vacuum that will be required to produce an efficient result. This is therefore but 1½ per cent. of the total horsepower output and this percentage has been deducted from the economies on curve *A*.

From the above performance curves it would appear that the engine-turbine combination has an advantage over the single compound-condensing engine unit even where the power factor is close to the designed point and where no exhaust steam is required for heating purposes. It is also readily seen that where a given quantity of low-pressure steam is required which is completely utilized in the plant to be charged against the engine economies, considerably better results are obtained from the turbine-engine combination than would be possible where a cross-compound engine were operating condensing and the low-pressure steam taken direct from the boiler through a reducing valve. Some of the further economies that would be obtained from a plant of this kind would be very difficult to estimate but would undoubtedly show large savings over the older methods; for instance, in the case of the steam-driven air compressor where the exhaust under ordinary conditions would not be re-

quired. It might generally be stated that if the compressor were taking 45 pounds of steam per actual horsepower-hour, which would be quite reasonable, this would generate over one electrical horsepower on the low-pressure turbine after making liberal allowance for loss in condensation, etc. Further, even if this compressor were operating condensing, it could be shown that a better result would be obtained by combining the compressor with the mixed-pressure turbine as in the case of the engine.

power was assumed at full load, and the same figure for three-quarter load, while at half load a consumption of 27½ pounds per indicated horsepower with 35 pounds at quarter load. The same percentage of mechanical efficiency was taken at 94.

The steam pressure in both cases is based on 130 pounds at the engine and the vacuum in the case of the compound engine to be maintained at 26 inches, while that on the turbine is to be 27 inches. It is also to be understood that 13 per cent. of the total exhaust from the noncon-

for the compound-condensing engine and $7280 for the noncondensing engine and turbine, or a saving of $330 in favor of the engine and turbine. Where 2000 pounds of exhaust steam per hour is required for heating purposes six months in the year, the total costs of coal would then be for the compound-condensing engine $8360 and for the noncondensing engine and turbine $7680, or a saving of $680 in favor of the engine and turbine combination.

Taking a basis of load factor of 78

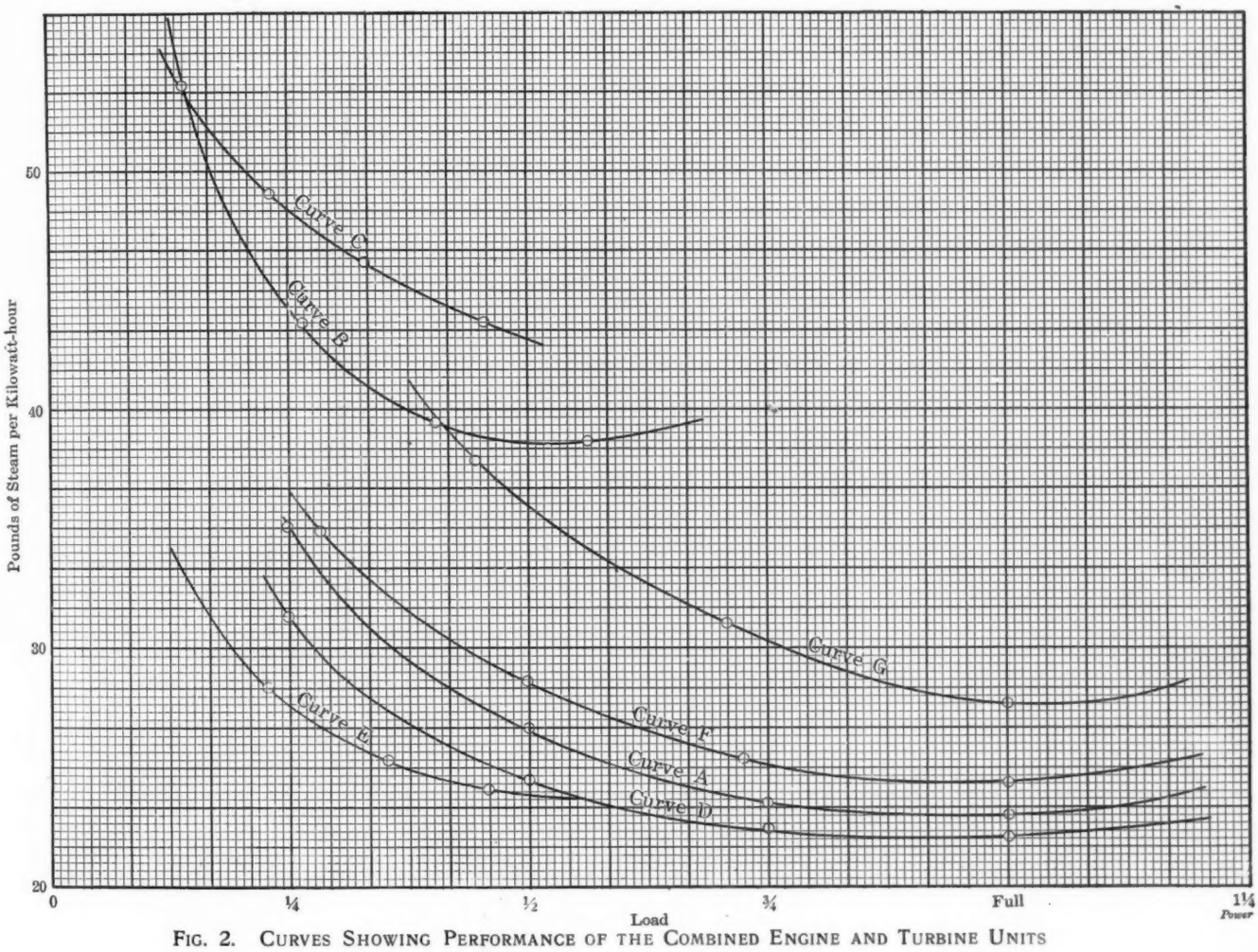


FIG. 2. CURVES SHOWING PERFORMANCE OF THE COMBINED ENGINE AND TURBINE UNITS

To make clear the basis of the steam-engine results given in curves *A* and *B* the following data were used, it being understood that these figures represent the actual commercial performance of the reciprocating engines and not test results when everything is keyed up to produce the top-notch of economy. For the cross-compound engine a steam consumption at full load of 14½ pounds per indicated horsepower was assumed and this also carried on to three-quarter load. For the half-load reading 16½ pounds per indicated horsepower was assumed and for the quarter load 23 pounds. The mechanical efficiency, as before stated, was taken at 94 per cent. and held constant at all loads. In the case of the simple engine 25 pounds per indicated horse-

densing engine under full load was assumed as having been lost from condensation. It is believed that this figure is conservative and is not likely to vary more than a per cent. or two each way where the exhaust pipe between engine and turbine is short and is free from unnecessary bends.

To sum up the net results of these two types of plants, we will assume two or three different load factors and an operation of 3000 hours per year, the cost of coal to be $3 a short ton delivered and the ratio of evaporation 7½ pounds of water to one pound of coal. With 110 per cent. load factor, or 1,485,000 kilowatt-hours per annum, the cost of coal, provided no exhaust steam is required all the year round, would be $7610

per cent. for the same 3000 hours, the cost of coal for the compound-condensing engine where no exhaust is required, would be $5400 and $5150 for the noncondensing engine and turbine, or a saving in favor of the engine and turbine of $250. Where 2000 pounds of exhaust steam is required for six months, the coal for the condensing engine would amount to $6150 and for the noncondensing engine and turbine $5460, or a saving of $690 in favor of the engine and turbine.

Taking a third case where the load factor is 56 per cent. and under the same conditions as in the previous two examples where no exhaust is required, the engine and turbine combination shows a decrease in cost of coal over the compound-condensing engine of $300; and

where 2000 pounds of steam per hour is required on a basis of six months' operation, the saving then increases to $730 in favor of the engine and turbine. As before stated, no account has been taken in these coal costs of the slight increase of coal required for boiler-feed pumps, vacuum pump, etc., because this would be the same in both examples; moreover, the additional coal consumption would be very slight because the exhausts of either of these auxiliaries would be utilized for heating the feed water. It will be readily seen, however, from the above figures and curves that there are many plants whereby these differences in efficiency in favor of the turbine-engine combination would become considerably greater than that shown above where further supplies of exhaust steam could be obtained for the turbine that have hitherto been exhausting to waste.

The question of comparative costs of these two plants will now be taken up, and the writer will endeavor to show that the engine-turbine combination will cost no more than the cross-compound engine and generator having the combined capacity of the other two units. I estimate the costs of the two plants as follows:

CROSS-COMPOUND CONDENSER ENGINE PLANT.

700-horsepower engine delivered and started	$11,000
450-kilowatt, 100 revolutions per minute generator	6,500
Foundation	750
Condenser	1,500
Total	$19,750

COMBINED ENGINE AND TURBINE PLANT.

Single engine complete with 250-kilowatt generator	$6,500
200-kilowatt mixed-pressure turbine	9,000
Foundations	500
Condenser	2,000
Total	$18,000

The above estimate is possibly open to slight modification in the costs of the engines, but the writer believes that the comparative values are just. The difference of $1750 should take care of the further amount of piping required in the combined engine and turbine plant together with additional cost of generator panel, etc.

Before closing, it might be well to enumerate some of the advantages and disadvantages of this combined engine and turbine installation and leave it to the commercial engineers and manufacturers to decide for themselves which is the most favorable installation under their conditions. The claims that can be made for the turbine-engine combination would be:

First, the great degree of elasticity which this type of plant offers over the single compound-condensing engine plant. The consumption curve is shown to be a very flat one for a very large range of load and a fine economy can be maintained even at quarter load by shutting down the engine and operating the turbine as a straight high-pressure condensing turbine with the resultant economies as shown in curve *E*. It is often the case in a manufacturing plant during overtime that a small proportion of load is required and the reciprocating engines show poor efficiency when considerably underloaded.

Secondly, that in the case of a breakdown of either unit, the remaining unit could always handle the greater portion of the load until repairs could be made.

Thirdly, that it is a type of plant that will retain its inherent efficiency for a longer period than an engine because any drop in efficiency which would take place in the engine due to leaking valves, valve setting becoming disarranged, leaky pistons, etc., would be taken care of in the turbine because the greater amount of exhaust steam would produce the greater output from the latter unit.

Fourth, the very obvious advantage over the condensing engine where exhaust steam is required for heating purposes during a portion of the year or where a steady supply of low-pressure steam is required for manufacturing purposes during the total period of operation. It would be impossible to duplicate the results which can be obtained from this engine and turbine combination, by any means of low-pressure steam generation or by operating the main unit noncondensing. Even if a small generating set were installed and operated noncondensing, all the exhaust of which was used, I do not believe that the net results would equal those shown in the curves submitted in the case of the engine-turbine combination.

The main disadvantage that could be urged against the combined engine-turbine plant would be the larger number of parts and possibly a greater amount of steam piping to take care of, in the matter of repairs, standing charges, etc.

In conclusion, the writer believes that there is an immense field for the independent mixed-pressure turbine to operate in connection with either existing reciprocating engines or as part of an original installation, and particularly in moderate-sized manufacturing plants where the normal horsepower output varies anywhere from 300 to 1000. The subject of economies in small plants has been a much neglected one and it would be a reasonable statement to make that probably nine small plant owners out of ten are not aware of, and have very little interest in, the economies of their power plant outside of paying, under protest, the large coal bills which are so often prevalent.

Steam Chest Diagrams

Indicator diagrams are frequently received with the inquiry "Why is the steam line so much below boiler pressure?" As water will not flow unless there is a difference in level, so steam will not flow from the boiler to the engine cylinder without there is a difference of pressure between them. This being true, the pressure in the cylinder must always be lower than that in the boiler. Engines with piston speeds so low, and supply pipes so large that the flow of steam to the cylinder will be rapid enough to give a steam line in the indicator diagram so closely approximating boiler pressure as to appear to be identical with it, are sometimes seen; but they are the exception rather than the rule. Steam passages to the cylinder are usually designed with reference to the piston speed and area and of such proportions that the velocity of flow of the steam shall not exceed 6000 feet per minute. If the flow much exceeds this speed the pressure in the cylinder must be appreciably below that in the boiler, even if connected by the shortest and most direct pipe line practicable, and this difference is increased by long and small piping with numerous bends the crooked path through throttle valves of the globe pattern and by restricted passages in the cylinder itself.

Another factor which has apparently attracted little attention is the elasticity of the steam. As the steam valve opens, the steam having a larger space to fill expands, reducing the pressure in the immediate vicinity of the cylinder. The pressure here being lower than in the boiler, a flow from the boiler toward the cylinder begins. When the steam valve closes, this flow is checked at the cylinder end of the pipe. But the steam being elastic, that portion in the boiler end of the pipe continues to move toward the cylinder for some time after the steam in the cylinder end of the pipe has stopped, by its momentum compressing the steam near the cylinder and sometimes raising the pressure above that in the boiler. Then the flow starts in the opposite direction, and at about this time the steam valve at the other end of the cylinder opens and the process is repeated. If an indicator be attached to the steam chest and a diagram taken, the pulsations of pressure due to the alternate stopping and starting of the body of steam between the boiler and the cylinder will be clearly delineated. The steam-chest diagram usually takes the form of a double elongated loop and if taken on the same card with a diagram from the cylinder its relation to and influence upon the steam line of the cylinder diagram may be readily seen. Steam-pipe diameters may be increased and steam ports enlarged but between the steam line of the cylinder diagram and the boiler-pressure line an appreciable difference in hight may always be expected.

Test Engine for University of Nebraska

There has recently been furnished for the University of Nebraska, at Lincoln, by the Murray Iron Works Company, of Burlington, Ia., a test engine. It is a cross-compound engine with cylinders 10 and 20 inches in diameter by 24 inches stroke. Both the high- and low-pressure cylinders are designed to withstand a steam pressure of 175 pounds gage per square inch after one reboring, and are steam jacketed on both barrel and head, with expansion ring cast with the cylinder jacket.

Each frame is cast in one piece with the guide which is bored; and like all of the engines made by this company the main bearings are adjustable both vertically and horizontally.

Both frame and cylinder bases are of the pedestal type with oil-retaining rim, which at the cylinder end extends under the valve gear and to which the accident-proof dashpots are bolted.

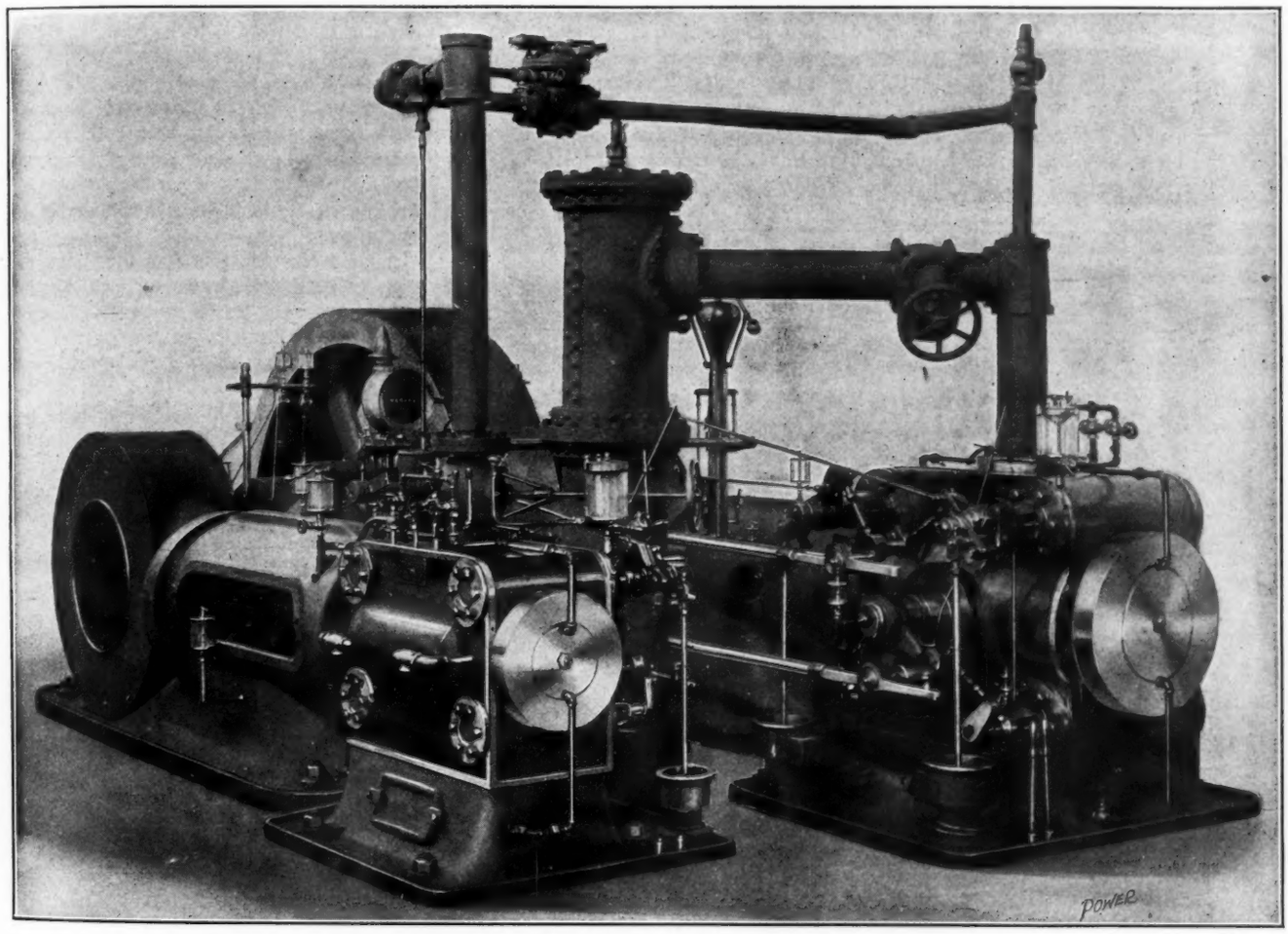
The flywheel with turned and polished rim is 8 feet in diameter by 16 inches face, with return flange 4 inches deep for the purpose of retaining cooling water when a prony brake is used, and is secured to the shaft by four bolts through the split hub. The shaft, which is 94¾ inches from center line to center line of engine, is of mild steel 9 inches in diameter at wheel fit, with main bearings 7x14 inches.

The valve ports are unusually wide to allow for full pressure on the piston while running at a high rate of speed. The exhaust valves are cylindrical, filling the valve chambers, and have the steam passages through them, reducing the clearance in the exhaust ports to a minimum amount.

There are two eccentrics for each cylinder, giving a wide range of steam distribution, and a cutoff under the control of the governor up to five-eighths of the stroke.

The high-speed center-weighted governor is attached to the low-pressure frame with roller-bearing cross shaft to the high-pressure side. The cutoff on the low-pressure cylinder is adjustable, giving any desired receiver pressure.

Pipe connections between high- and low-pressure cylinders, main steam pipe and receiver, exhaust passages and condenser are fitted with valves so that either or both cylinders may be operated condensing or noncondensing, simple or compound, with or without steam in the reheating tubes in the receiver and in the jackets.



MURRAY IRON WORKS CORLISS ENGINE, BUILT FOR THE UNIVERSITY OF NEBRASKA

There are 10 different sizes of pulleys for the governor shaft, giving a range of speed from 60 to 150 revolutions per minute. On the governor column there is a steel scale graduated in hundredths of an inch over which passes a pointer attached to the governor, permitting the reading of the governor hight at all times.

As may be seen from the illustration, the engine is designed for use in a mechanical laboratory where exhaustive experiments may be made under all possible conditions of load variation and steam distribution.

Steam Velocities and Size of Pipe

With Steam Pressures of 125 to 150 Pounds and Moderate Superheat, Velocities of 8000 to 9000 Feet per Minute Are None Too Great and with Turbines 12,000 Feet Is Feasible

BY C. J. LARSON

There is much diversity of opinion as to what constitutes proper pipe sizes for central-station work. In general, however, it may be said that steam pipes are unnecessarily large. Builders of engines and turbines have taken pains to have steam connections ample, so as to guard against possible cases of excessive drop in pressure, and it has been almost universal practice never to reduce a steam pipe below that called for by the nozzle on the machine. On the contrary, the pipe has very often been increased.

In modern reciprocating engines, cutoff occurs in the early part of the stroke. This means that steam is flowing in the steam pipe only a fraction of the time, and the pipe must of necessity be large, to prevent excessive drop in pressure during the period of admission. More satisfactory results can be obtained by placing a receiver several times the capacity of the cylinder, as near as practicable to the latter. The pipe leading to the receiver can then be much reduced, as steam will be flowing through it continuously into the receiver, which acts as storage capacity. Where saturated steam is used, the receiver also answers the additional purpose of a separator. The above arrangement is also equally adapted to steam turbines equipped with the "puff" system of steam admission. The receiver also serves the purpose of relieving the piping and connections of the shock, caused by the intermittent flow of steam.

In many existing power stations, the main steam headers are unnecessarily large. In some cases, the sectional area of the header is made equal to the sum of the areas of all the branch pipes from the boilers. The header generally acts simply as an equalizer, and the actual flow of steam in it is less than in the various branch pipes. In exceptional cases it is possible to place the header near prime movers. If this is practicable, the larger header becomes of value as a receiver, but ordinarily the steam header need be little, if any, larger than the branch pipes leading from it.

When steam turbines are controlled by throttling governors or by varying the number of steam nozzles in operation, the size of supply pipe can be much reduced below that required for reciprocating engines or puff-controlled turbines, because the steam flows continuously.

Until quite recently steam velocities in pipes of 6000 feet per minute were considered high, and most piping was designed for 4000 feet or less, but it has been demonstrated that higher velocities are entirely permissible; and the losses from radiation are thereby considerably reduced. This is especially true of highly superheated steam.

Where the steam is moderately superheated, 75 to 125 degrees Fahrenheit, with boiler pressures of 125 to 150 pounds, steam velocities of 8000 to 9000 feet per minute are none too great, while with turbines using continuous flow, velocities of 12,000 feet per minute are entirely feasible, provided the piping is free from short bends and not excessively long. With higher steam pressures and greater superheat, these velocities can safely be increased.

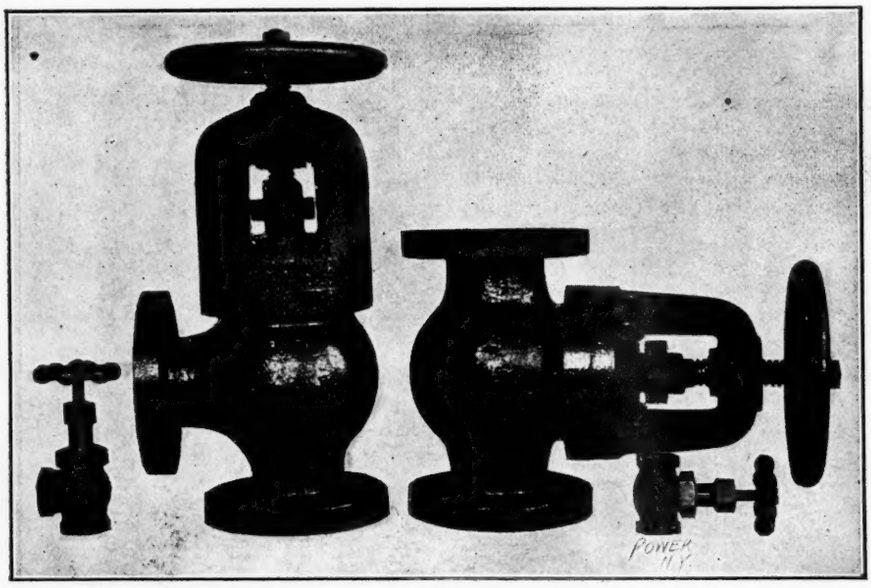
The writer has used temporary steam piping on turbines, with steam at 200 pounds pressure and 150 degrees superheat, in which the velocity was regularly over 20,000 feet per minute. No means were available for determining the loss in efficiency due to these extreme conditions; but operation was satisfactory, there was no apparent loss of economy, and there were no deteriorating effects on the piping noticeable after months of operation.

Considering the fact that the time percentage of the peak load in most central stations is very small, one can afford to sacrifice efficiency by employing extreme steam velocities during these periods; for the cost of piping and fittings increases rapidly with their sizes, and the losses from radiation increase with the surfaces exposed.

The steam piping to nearly all auxiliary units, even in the thoroughly modern power station, seems to be absurdly large. Such apparatus as feed and condenser pumps, fan, circulating and stoker engines, etc., will almost invariably be found with their controlling valves, whether hand operated or automatic, barely opened. It is also a fact that if the valves were opened wide, a large percentage of such units would be wrecked through excessive speed, because the steam pressure necessary to operate such apparatus is usually only a fraction of that available.

The accompanying photograph shows two 2½-inch throttle valves that were removed from boiler-feed pumps in a central station, also the ¾-inch throttles that were substituted. These valves operate the pumps at normal speed when less than one-third open. It may be said also that the relative cost of the above valves and piping was in quite close proximity to their comparative weights, which may be judged from the illustration.

Many of the steam-driven auxiliaries in general use are not designed to withstand the high steam pressures commonly carried in the modern power station, and to meet this condition the steam is passed through reducing valves. In some cases a reduced-pressure auxiliary piping system is employed, only one reducing valve being used. In other instances each unit, or group of units, has a reducing valve.



THE SMALLER VALVES TO REPLACE THE LARGER ONES

When automatic cutoff auxiliary engines are used the above method of reducing pressure is well adapted, but it should be remembered that by placing the reducing valve as near the engine as practicable the high-pressure section of the pipe can be very considerably reduced below that called for by the engine nozzle. Also the cost of the reducing valve and maintenance of the valve seats will be less, if the smaller size valve is employed.

But on all auxiliary engines equipped with throttling governors and on all pumps, whether governed by hand or automatic pressure regulators, the following method is simpler, cheaper and safer than those outlined above. Make the piping to each unit no larger than necessary to carry the maximum amount of steam (at boiler pressure), which the unit will need; and have the throttles, throttling governors or pressure regulators amply heavy to withstand boiler pressure, and of the same size as the steam pipe—not the size of the steam connection on the engine or pump. Then put a pop safety valve on the steam chest of each unit. This should be set slightly above the pressure necessary to operate the machine under normal conditions. This safety valve, which can be somewhat smaller than the size of the steam pipe, serves the triple function of protecting the steam chest and cylinder from excessive pressure, of serving as a check on the pressure and consequently speed in the case of a deranged governor; and third, it gives instant warning, in case of unusual pressure, which can be both seen and heard, and thus give double evidence of the trouble.

Prony Brake Horsepower Curves

Several months ago some prony-brake horsepower curves plotted for one particular brake arm, namely 5 feet 3 inches, appeared in POWER. While this length of brake arm has many advantages in the computation of the readings of the brake, conditions might arise when such a length could not be used. Herewith is given a chart in which any length of brake arm may be used from 0 to 100 inches, the weight on the brake may vary from 0 to 600 pounds, and the speed may vary from 0 to 1200 revolutions per minute. The curves are merely a graphical representation of the prony-brake formula,

$$H.P. = \frac{(2\pi DWN)}{12 \times 33{,}000},$$

where

D = Length of arm in inches,

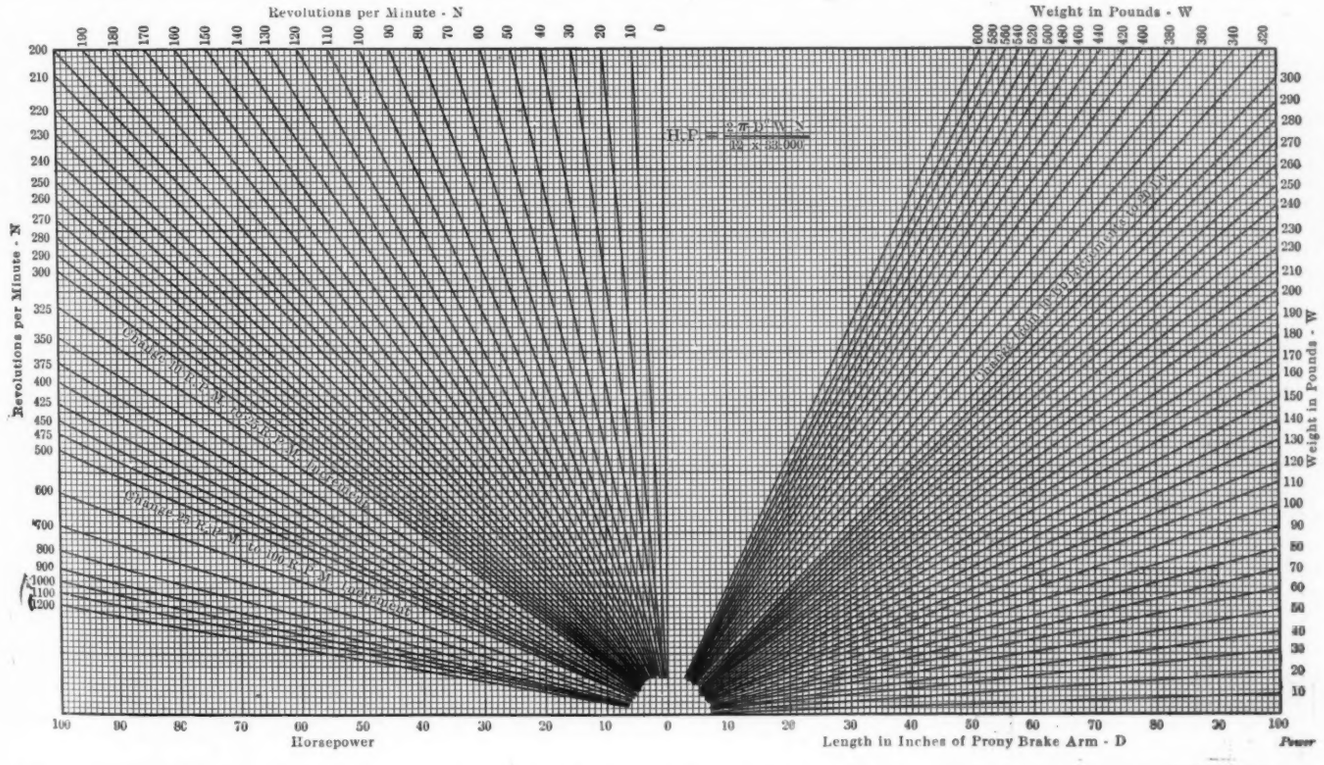
N = Revolutions per minute,

W = Weight in pounds.

The use of the curve is very simple. Suppose a certain prony brake is 80 inches long and when applied to a particular engine running at 200 revolutions per minute, the weight on the brake is 180 pounds. From the curve find 80 inches on brake-arm length, run up to 180 pounds and over to 200 revolutions per minute and then down to 45.6 horsepower. Computation of the problem by the formula above gives 45.8 horsepower.

$$H.P. = \frac{2\pi \times 80 \times 200 \times 180}{12 \times 33{,}000} = 45.8 \text{ horsepower.}$$

Curves of this nature are not to be used when accurate results are required, and in all cases where accuracy is essential a computation should be made. For approximate results the accompanying chart is sufficiently accurate, and will save much of the time required in calculation.


Revolutions per Minute - N
Weight in Pounds - W
Revolutions per Minute - N
Horsepower
Length in Inches of Prony Brake Arm - D
Weight in Pounds - W
Power

The effect of soot on the evaporation of a horizontal tubular boiler is shown by some trials made in which during the first series soot was allowed to remain on the tubes and in the second series the tubes were cleaned in the morning. With the soot allowed to accumulate the evaporation from and at 212 degrees per pound of dry coal was 6.2 pounds, the dry coal per square foot of grate surface 13.4, and the temperature of the escaping gases 627 degrees Fahrenheit. With the tubes cleaned, the evaporation from and at 212 degrees per pound of dry coal was 7.04 pounds of water and the dry coal per square foot of grate surface per hour was 9.09 pounds.

A Furnace for Tanbark and Similar Fuels

In Which Provision Is Made to Avoid Deterioration of Brickwork around the Bottom of the Stokeholes and in the Side Walls of the Furnace near the Grate

In discussing a paper upon the above subject presented by David Moffat Myers to the American Society of Mechanical Engineers at its December meeting, A. A. Cary described a furnace which has been for a long time in successful use for this purpose, drawings of which are now available and reproduced herewith.

The type described by Mr. Myers consists of extension furnaces, projecting in front of the regular boiler settings, with a number of circular stokeholes, or openings through the top arch, over the grates, Mr. Cary says.

No little trouble has been experienced with this construction, due to destruction of the lower end of these circular firebrick tubes through which the fuel is charged to the furnace.

If these stokeholes could be constantly and completely filled with fuel, so as to prevent considerable inrushes of air through these openings, this destructive effect could be materially checked; but as the method of hand charging the fuel is an intermittent one, the upper end of the cone of spent tan bark, soon after charging, drops below the level of the top of the arch, and the inrushing air meets the hot furnace gases at these positions and intense combustion results here. Between this condition, and the condition when the excessive moisture in the fuel rises as a vapor against the arch, abstracting its heat rapidly (to become superheated steam) the firebrick cracks and disintegrates, finally resulting in a chipping off of the brickwork of the reverberatory arch around the lower end of these stokeholes, and repairs are, therefore, frequently necessary.

A continuous automatic feeding device, which would keep these stokehole openings constantly filled with the moist fuel would, undoubtedly, do much to relieve this trouble by preventing an excessive infiltration of air at frequent intervals of time.

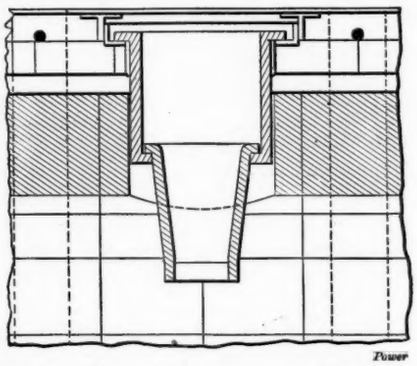


FIG. 2. CAST-IRON LINING FOR CIRCULAR STOKE HOLES

R. K. McMurray, of New York City, who has had a very extended experience with this class of furnace, has designed a very ingenious method of quite different design, for overcoming this trouble in hand-stoked furnaces.

Fig. 1 shows both front and side sectional elevations of the McMurray furnace.

He fits a circular lining, of cast iron, into the top of the stokehole, which does not drop down to the level of the inside of the arch, as shown in Fig. 2. The lining is finished with a flat ring, projecting radially, toward the center of the hole, diminishing its diameter of opening by about 2 inches. He then drops a separate tube or open thimble into this frame, which has a straight ledge, like the brim of a hat, cast around its upper end. This brim is caught and retained by the bottom ring of the stokehole frame, so that the bottom end of the tube hangs downward—a foot, more or less, into the furnace.

The fuel charged into the stokehole, falls through this lower tube, and forms a cone-like pile of the fuel below it, on the grates.

When the stoke hole becomes uncovered, the inrushing air causes the intense combustion to take place; not on a level with the brickwork, but at a lower level, below the inserted tube, and the life of the firebrick arch, at the stokehole openings is thus greatly prolonged.

The ends of the cast-iron inserted tubes burn off gradually, but they are cheap, and easily pulled out and new ones are inserted in their place with very little trouble.

Another trouble met with in this type of furnace is the rapid burning away of the fuel next to the side walls of the furnace and the consequent large infiltration of air, from the ashpit, through these openings at the sides of the grate surface.

This trouble has been largely overcome by reducing the width of the furnace (by about 1 foot) at the grate level, as shown in the front sectional elevation of Fig. 1.

The ledges formed on either side of

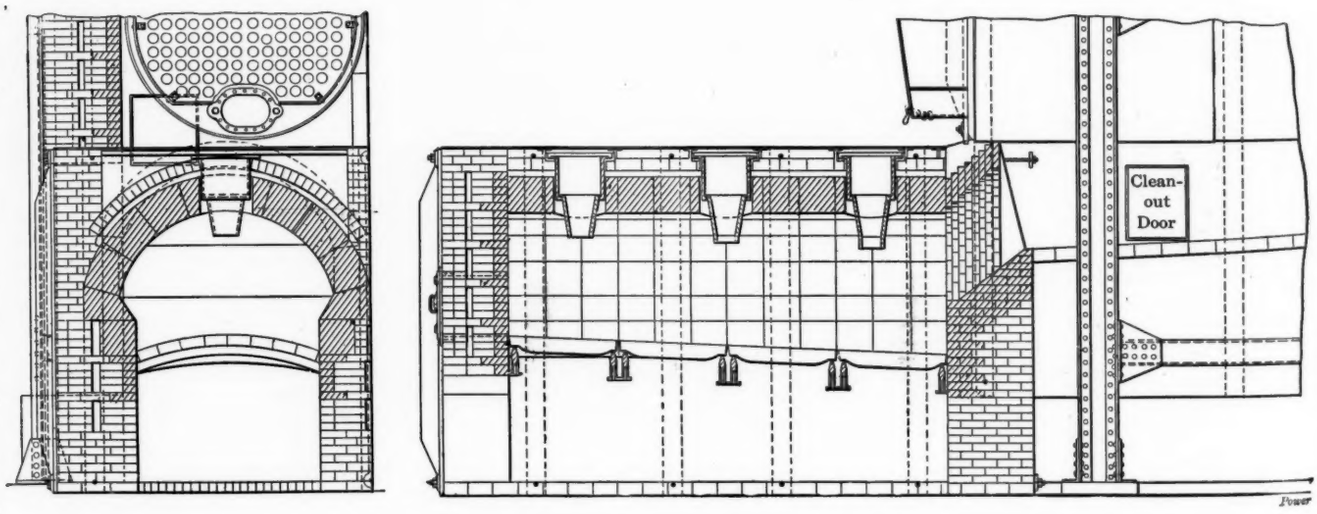


FIG. 1. MCMURRAY FURNACE FOR BURNING SPENT TANBARK

the lower part of the furnace are thus made to support the cone of charged fuel on each side, thus keeping the grate below effectually covered with fuel.

In this construction it will also be seen that instead of using a flat grate, the grate-bearing bars are curved upward toward the center, so that the grate surface is higher at the center of the furnace than at the sides. This design decreases the thickness of the fuel bed under the stoke-holes and causes a thickening of the fuel bed at the sides of the furnace.

There certainly is no place where water can be evaporated at a greater loss than in the furnace itself and, therefore, every practical facility for depriving wet fuel of its moisture should be taken advantage of in order to obtain the best results.

Mr. Myers has spoken of the comparatively small gain resulting from the use of presses for reducing the moisture in the spent tan. I have used (with a desirable gain resulting) special rolls for extracting water from moist fuel. These rolls are quite similar to the well known rubber mixing rolls; running in pairs and with one cast-iron roll about 12 inches in diameter, while the other is about 14 inches in diameter, both being held together by heavy springs.

The faces of these rolls are roughened by having a shallow checkerwork pattern cast upon them.

The fuel is fed to the rolls continuously and due to the tearing or macerating action between the roll faces more than double the amount of water is worked out, as compared with the press results given in Mr. Myers' paper.

In one case, where the chimney was located some distance from the boilers, I used a wrought-iron rectangular flue to connect them and formed a shallow iron trough upon the top surface of the flue by having the edges on the two vertical sides continued above the level of the top of the flue. The other three sides of the flue were covered with a nonconducting covering. The moist fuel was fed upon the chimney end of the flue and by an automatic dragging conveyer, it was fed toward the boiler, then over the top of the boiler whence it was delivered on top of the extension furnace.

The heat radiating from the top of the boiler may be utilized in this way as well as the heat radiating from the top of the extension furnace.

I have also utilized the waste heat from the boiler to preheat the air delivered to the ashpit, and I know of no condition where preheated air can be used to better advantage than with moist fuels.

Mr. Myers has spoken of the advantage found in the use of the high-furnace as compared with the low-furnace construction.

My experience thoroughly indorses this finding and it is but reasonable to look for such results from a mere theoretical reasoning, as the large amount of steam evolved, when the moist fuel is charged into the hot furnace, produces a cloud of steam. This newly formed steam is next crowded down upon the burning fuel in a low furnace, followed by a suppression of combustion. A sufficient amount of steam would eventually extinguish the fire.

The entire effect of moisture found in the spent-tan furnace is not summed up in Mr. Myers' paper, as there is also the additional effect of interference with the combination of oxygen and the combustible gases, evolved from the fuel, due to the large percentage of the space occupied by the steam in the combustion chamber.

In the flue-gas analyses obtained with moist fuels, the water in the gases, of course, condenses and is not accounted for in the analyses given.

Experience has taught me that it is equally important to determine the percentage of moisture contained in such gases, as it is to determine the CO_2, O, and CO, and such added information will assist materially in furnace improvement and operation.

I have found that the best results, in burning moist fuels, are obtained at comparatively high rates of combustion, and, therefore, such furnace dimensions should be reduced to their smallest practical proportions, and extended grate surfaces should be avoided.

Recent experiments in burning spent-tanbark, conducted by the Murphy Furnace Company, using the Murphy type of furnace, have proved quite successful.

Although the Murphy type of furnace depends upon the coking method of firing, coking the spent-tan fuel is not attempted; but the method of feeding the fuel to the grates peculiar to this type of furnace, lends itself very effectually to the automatic feeding of the spent tan to the grates located beneath the fire-brick arch.

Figuring the Economy of Economizers

BY GEORGE H. GIBSON

The actual saving in fuel realized by preheating boiler-feed water has been the subject of acrimonious dispute. At one extreme are the live-steam heater advocates who claim that the number of pounds of coal required to turn 100 pounds of water into steam can be reduced by taking heat units out of the boiler as live steam and putting them back again in the feed water, while on the other hand, R. P. Bolton, in an article published some time ago, seemed to contend that the gain in fuel economy from the utilization of waste heat by economizers is less than would be computed from the percentage of heat supplied by preheaters.

Tests on economizers are practically unanimous in showing that the saving in coal is greater than would be anticipated from the proportion which the heat units recovered bear to the total heat units imparted to the feed water to convert it to steam at boiler pressure. For example, let us suppose that on entering the economizer the water has a temperature of 90 degrees Fahrenheit, and that it leaves at 250 degrees Fahrenheit. Then 160 B.t.u. will be imparted to each pound of water passing through. The total heat required to evaporate a pound of water at 90 degrees Fahrenheit to steam at 100 pounds gage is 1128 units, of which 887.5 are consumed in the actual evaporation and 240.5 in raising the cold water to the boiler evaporating temperature. The 160 heat units supplied by the preheater make 14.2 per cent. of the whole, or roughly, for every 11 degrees Fahrenheit added to the temperature of the feed water, 1 per cent. of fuel should be saved, assuming that the boiler efficiency remains as before.

Now, as a matter of fact, careful comparative tests in steam plants, first with the fuel economizers in service and then without, have nearly always shown that the coal saving has been better than this, or about 1 per cent. for every 8 or 9 degrees Fahrenheit added to the temperature of the feed water. Furthermore, a rational explanation of this fact does not appear impossible. Mr. Bolton assumes that the lower the temperature at which the feed is introduced into the boiler the greater will be the average difference of temperature between the flame and the water, and the greater the rate of heat transfer. Suppose, however, that the feed water be introduced into the steam space in such manner that it is heated nearly, or quite, to steam temperature before mingling with the water already in the boiler; would the average difference between the flame and the water then be affected one way or the other by preheating the feed outside the boiler? Even if the feed water be not introduced into the steam space in commercial boilers, it is usually introduced at some point in the boiler distant from the most active heating surface, so that, considering its relatively small volume, it exerts but little influence upon the average temperature of the water next to the heat-trans-

mitting surfaces, at least while the boiler is actually making steam.

On the other hand, the introduction of the feed water into the boiler hot, instead of cold, should have a tendency to increase the efficiency of the boiler in and of itself, as follows:

Suppose that a boiler containing 1000 square feet of heating surface is delivering 100 brake horsepower, converting feed water at 90 degrees Fahrenheit into steam at 100 pounds pressure. Then suppose the feed water is heated to 250 degrees; the boiler heat-transmitting surface will thereby be relieved of 14.2 per cent. of its work of transmitting heat. If it is assumed that the temperature of the flue gases on the one side of the heat-transmitting surface and of the water on the other side remain the same as before, the boiler is in a position to transfer as much heat as before, that is, to make 14 per cent. more steam than before, with the same efficiency. If, however, the output of steam is adjusted to the same number of pounds as before, the consumption of coal and the rate of transmission of heat will be less; that is, the virtual rate at which the boiler is being driven has been reduced and a lesser temperature head will suffice to cause the flow of the lesser amount of heat through the resistance of the heating surface. A smaller difference of temperature between gases and water then suffices to cause the flow of the lesser number of heat units per hour through each square foot of heating surface, thereby implying a lower average temperature of flue gases and making it possible for the gases to leave the boiler at a lower temperature than when developing the same amount of steam from the same feed water without the assistance of the economizer.

Some time ago Dean & Main, of Boston, made tests on a 315-horsepower Babcock & Wilcox boiler at the Natick mills. With the Green economizer in service the average rise in temperature of the feed water was 125.4 degrees Fahrenheit, which, at 1 per cent. saving for each 11 degrees Fahrenheit, would correspond to a fuel economy of 11.4 per cent. Actually, as compared with the test made without the economizer, the saving was 13 per cent.

Tests carried out by George H. Barrus at the boiler plant of the Toronto Railway Company, which is equipped with Scotch marine boilers and fuel economizers, showed that with the economizer in service the average rise in temperature of the feed water was 136 degrees Fahrenheit, corresponding to a 12½ per cent. theoretical reduction in coal consumption. However, as compared with tests made on the same boiler with the economizers cut out, the saving due to the economizer represented 18 per cent. of the coal.

An elaborate series of tests made by F. G. Gasche at the Armour Packing Company's plant at Kansas City, Mo., which is equipped with Green economizers, showed a saving calculated on the rise in temperature of the feed water of 11.6 per cent., but an actual saving by comparison with the coal burned without the economizer of 17.5 per cent. In each of the above cases the savings are calculated from the coal required to evaporate a pound of water from and at 212 degrees Fahrenheit.

These results, and many others which could be adduced, fully support the view that the fuel saving from the installation of waste-heat feed-water heaters, such as the fuel economizer, is more than the ratio which the waste heat recovered bears to the total heat required to turn the feed water into steam.

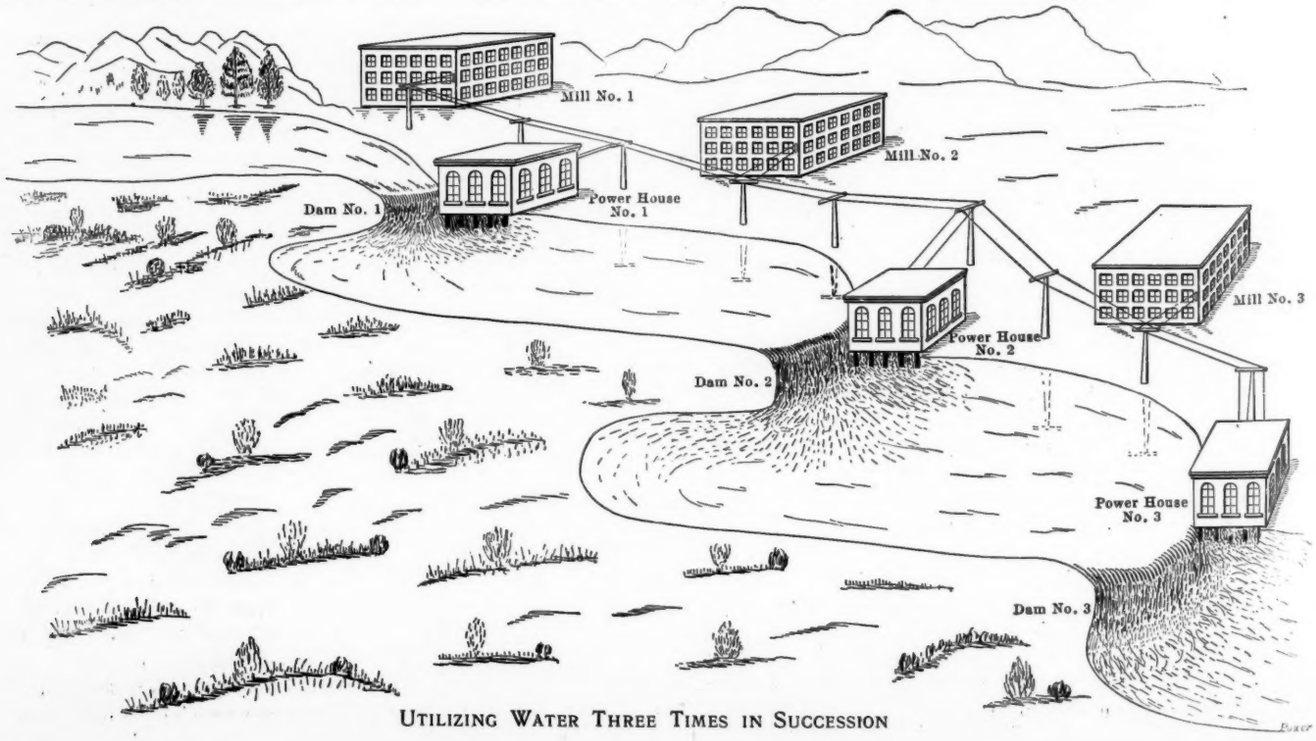
A Novel Application of Water Power

By Edward T. Binns

An instance of modern business sagacity in the matter of water-power economy may be found in New England, where three power plants are operated by a textile-manufacturing company for running three mills, which are situated about one and a half miles apart, the three stations furnishing electricity for them by means of three water turbines, direct connected with so-called water-wheel alternators.

During a considerable part of the year there is not sufficient water to run the mills from one of the stations for an entire day. At the time of my visit the water was exceedingly low, and all the water running in the creek was caught in the upper dam during the night. The upper station was started in the morning, carrying the three motor-driven mills until the water was nearly gone. The operator then telephoned to the center-station operator to put his machine on the line. When started up and the voltage equalized, No. 1 plant was cut out and shut down. The same procedure was carried out with No. 3 plant when the water for No. 2 plant got low.

The water was carried to the turbines by penstocks, one of which was 7 feet in diameter, having a fall of 60 feet. Shaft-driven governors regulated the amount of water admitted, so as to maintain a uniform speed.



Utilizing Water Three Times in Succession

ELECTRICAL DEPARTMENT

Especially conducted to be of Interest and Service to men in charge of Electrical equipment.

Primer of Electricity

E. M. F. of a Dynamo

As explained in a previous lesson, electromotive force (electric pressure) is generated in a dynamo by the motion of wires on the armature in front of the poles of a powerful magnet. This magnet is called the "field magnet," because it creates a magnetic "field" in the space between the poleface and the armature core.

The space between the poleface and the armature core is called the "airgap." The e.m.f. generated by the armature conductors depends entirely upon the magnetic flux in the airgap and the velocity of the conductors through the flux.

The magnetic flux in the airgap is not distributed uniformly over the airgap area. Many technical writers describe the paths of the magnetic lines of force as straight parallel lines, as illustrated by the dotted lines between the *N* pole and the armature in Fig. 40, and calculate the individual electromotive forces generated by wires on different parts of the armature as though that were true. This is an unnecessary refinement, because it makes no difference in the practical operation of the machine whether the magnetic distribution is like that shown under the *N* pole, or like that shown under the *S* pole, or some other way. And in actual work, it is always some other way.

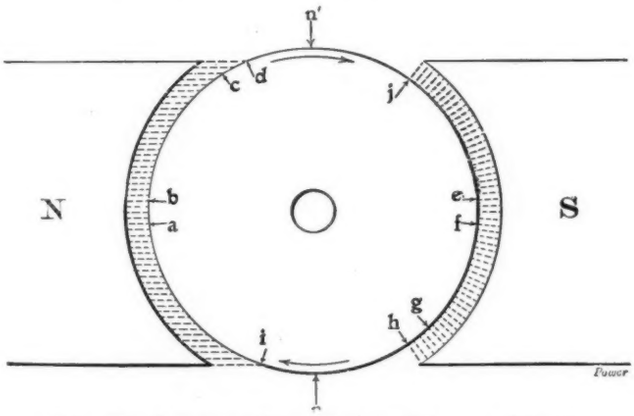


Fig. 40. Assumed Flux Distributions in Airgap

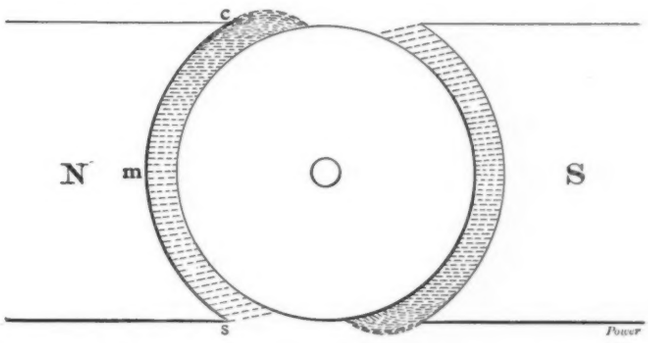


Fig. 41. Approximate Representation of Actual Flux Distribution

Suppose the distribution were as shown under the *N* pole and each dotted line represented 100,000 magnetic lines of force. Then in traveling from *a* to *b*, an armature conductor would "cut" 400,000 lines of flux, while in traveling the same distance from *c* to *d* it would cut only 200,000 lines. If the armature were driven at 600 revolutions per minute, a conductor moving from *a* to *b* would generate 1.76 volts, while another conductor moving from *c* to *d* would generate only 0.88 of a volt. The conductors in between these two would be cutting lines at gradually decreasing rates, reckoning from *a* to *d*, and the *average* e.m.f. generated in each conductor, moving through a distance equal to *a*—*b*, would be 1.3961 volts. That is, if there were 82 conductors in series between the points *i* and *d*, the total e.m.f. generated by all of them would be $82 \times 1.3961 = 114.48$ volts.

If there were 82 conductors between the points *i* and *d*, there would be 108 conductors on the complete half-circumference of the core, from *n* to *n'*, but the 13 conductors between *n* and *i* would be generating no e.m.f. and the other 13 between *d* and *n'* would also be idle. Therefore the total e.m.f. generated by the half of the winding on the left-hand circumference of the core would be 114.48 volts.

Now suppose the distribution were as shown under the *S* pole. Here, only 66 wires out of the 108 on that half of the armature are in the magnetic field at any one instant. Therefore, all of the e.m.f. has to be generated by those 66 wires. But with this distribution each wire cuts just as much flux in passing from *g* to *h* as it does in passing from *e* to *f*. In other words, every wire generates the same e.m.f. at every point of its travel.

The flux density is not quite so great between *e* and *f* as it was between *a* and *b* with the other theoretical distribution. Though the diagram could not be drawn so as to show it, the number of lines cut by a wire moving from *e* to *f* would be a trifle less than 3942, as compared with 4000 from *a* to *b*. At 600 revolutions per minute, each wire would generate 1.7345 volts while moving through the field from *j* to *h*, and this would not vary, because it is assumed that the field is uniform. The 66 wires under the poleface at any instant would be generating $66 \times 1.7345 = 114.48$ volts while the remaining 42 wires between the points *n'* and *j* and the points *h* and *n* would be idle.

From these two examples it is evident that the way the magnetic flux distributes itself in the airgap does not affect the total e.m.f. generated in the armature; it merely affects the division of the total e.m.f. between the individual wires on the armature.

The magnetic flux in the airgap of a dynamo does not distribute itself at all like either of the representations in Fig. 40. It is perhaps more nearly as represented under the *N* pole than the other way, but neither arrangement is correct and it is not practical to make a diagram that will show the flux distribution for all cases, because it differs considerably in different dynamos. For reasons that will be explained later, the flux tends to crowd to one edge of each poleface, as represented roughly by the dotted lines in Fig. 41, and the density is therefore less and less from the crowded edge *c* around to the other edge *s* of each poleface. This is about as close as it is practicable to come to a diagram that will apply generally.

As intimated before, the distribution of the flux in the airgap need not be considered in everyday work, except to a very limited extent. The *average* e.m.f. generated by a wire moving through a magnetic field is equal to the total flux in the field divided by 100,000,000 times the number of seconds required to pass through the field. It is probably easier to grasp this rule, however, when stated this way:

The average e.m.f. generated by a wire cutting through a magnetic field is equal to the number of lines of force cut per second, divided by 100,000,000.

For example, in Fig. 40 there are 5,300,000 lines of force in each airgap; if the armature makes 600 revolutions per minute, that will be 10 revolutions per second and each wire will cut 5,300,000 lines twice per revolution or 20 times per second. Consequently, each wire will cut

$$20 \times 5{,}300{,}000 = 106{,}000{,}000$$

lines of force per second and generate an average e.m.f. of 1.06 volts.

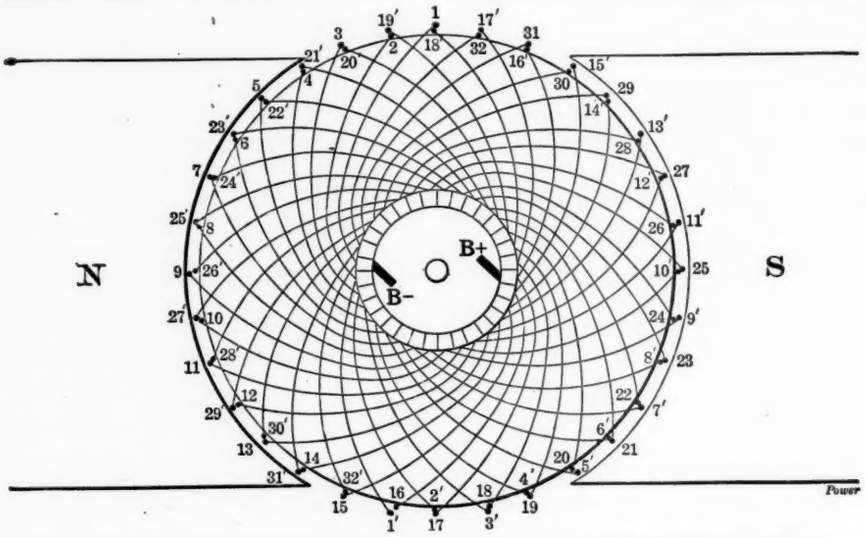


FIG. 42. TWO-COURSE ARMATURE WINDING WITH TWO PARALLEL PATHS THROUGH IT

With 216 wires on the armature, 108 would be in series in one half of the armature winding and 108 in series in the other half, the two groups of 108 wires each being connected in parallel by the brushes, as explained in the preceding lesson. The e.m.f. generated by 108 wires in series would be

$$108 \times 1.06 = 114.48 \textit{ volts},$$

which agrees with the two examples just given.

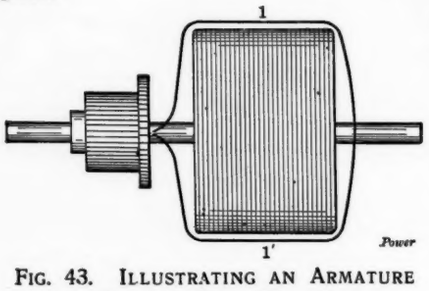


FIG. 43. ILLUSTRATING AN ARMATURE COIL OF ONE "TURN"

The statement that the wires in the armature winding would be divided into two parallel groups, each containing one-half of the whole number of wires in series, may be better understood by referring to Fig. 42, which shows a two-course winding containing 32 coils, each of one turn; consequently there are 64 wires on the armature, and by tracing from brush to brush through the winding it will be found that there are two paths, each including 32 wires in series. As in a previous diagram, the brushes are shown inside the commutator instead of outside, in order to avoid confusion in following the connections between the commutator and the wires.

From previous examples, it will be understood that each two wires on opposite sides of the armature core bearing the same number are connected across the back end of the armature core, and form one "coil" of the winding. For example, the wire marked 1 and that marked 1′ are connected across the back end of the core to form a one-turn coil or loop, as indicated in Fig. 43 (in small armatures one continuous wire is carried from the commutator around the core and back). The path through the armature winding from the brush $B-$ to the brush $B+$, starting with coil 1, passes through all coils from 1 to 16 in regular numerical order, and as each coil provides two surface conductors, this path passes through 32 conductors. The other path passes through the coils 32 to 17 in backward numerical order: thus, 32′, 32, 31′, 31, 30′, 30, and so on, taking in 32 wires also.

The electromotive force generated in this armature winding, with a speed of 900 revolutions per minute and a magnetic flux of 12,000,000 lines of force under each pole would be 115.2 volts.

The general formula for e.m.f. generated in a dynamo armature is

$$\frac{\Phi N_w\, p\, rps}{100{,}000{,}000\, q} = E.$$

In this formula

Φ = Number of magnetic lines of force passing between one pole and the armature core,

N_w = Total number of wires all around the armature circumference,

p = Number of magnet poles,

q = Number of paths through the armature winding,

rps = Revolutions per *second.*

What the Recording Voltmeter Revealed

BY G. E. MILES

After I had been in charge of a certain light plant about a year I was provided with a recording voltmeter with which to check up the voltage on the various circuits. The meter was first installed at the station to determine how uniform the voltage was maintained there. During the day when the power load was fluctuating through a wide range the voltage was found to be very irregular, but when the lighting load came on in the evening the voltage was quite steady and remained so till about 10:30 when there was a change in the machines and then the regulation became bad again and remained so the rest of the night. At first I thought that it was due to the carelessness of the engineer on duty, as the load was the steadiest during this period and it should have been easy to maintain steady voltage, but he assured me that he tried his best and simply could not keep the voltage anywhere near steady. To ascertain what was wrong I went to the plant one night to see what I could do. I found that the rheostat had to be moved several spaces before the voltmeter would respond and then after it had reached the desired voltage it moved still farther. I decided that the trouble lay in the governor and accordingly went at it the first opportunity that was offered.

The engine was a high-speed one and I had often looked the governor over to learn how the spindle about which the weight oscillated received its lubrication, but could find no provisions whatever. As there had never been any complaint from the engineers about the governing qualities of this engine I had pressed the matter no further. Now I decided to look for the trouble at this point first. I found that the weight was held on the spindle by a disk which in turn was fastened on by two screws. When the disk was removed a roller bearing was revealed with rollers about ½x6 inches, These rollers were found to be badly gummed up and to lie in grooves in gum on the spindle. No provision had been made for lubricating them. A thorough cleaning and oiling of this bearing cured our trouble with the voltage regulation, but I have never been able to understand why none of the five different engineers who had had charge of this engine during the preceding year had discovered anything wrong with the governor or the voltage regulation. As this machine was very seldom on till late at night, the poor regulation was not discovered in the lighting service. The trouble must have existed for a long time judging from the condition of the bearing.

LETTERS

Correcting Reversed Polarity

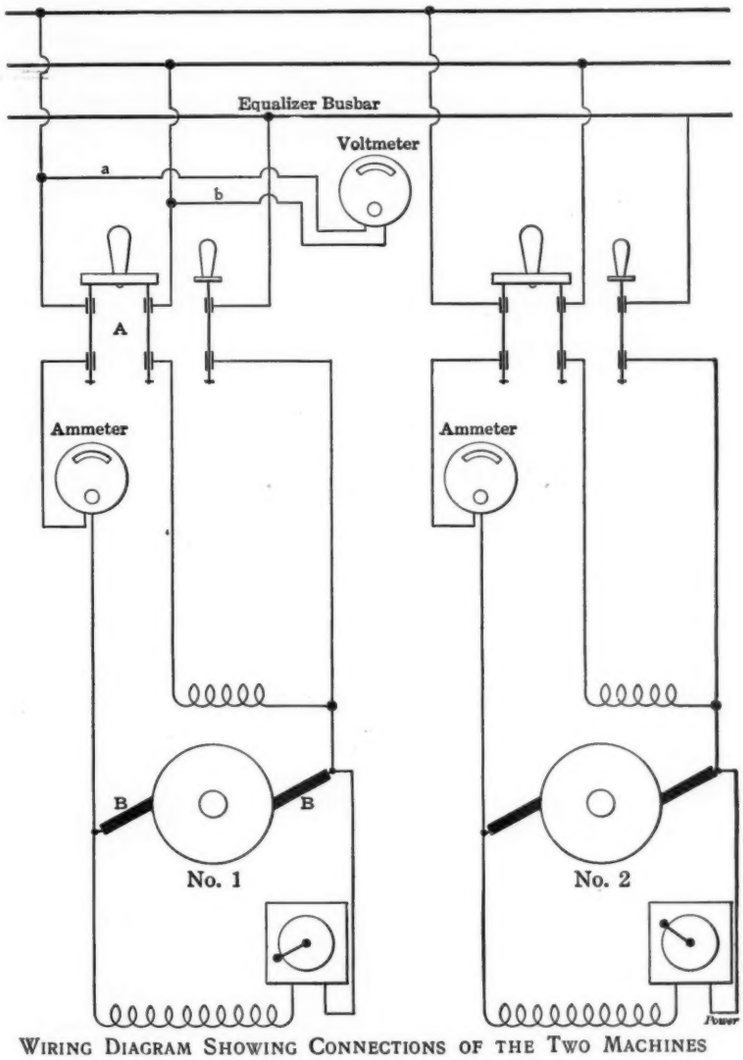
We have a couple of 50-kilowatt compound-wound direct-current generators. No. 1 is driven from the main engine shaft through a system of countershafts which step the speed up from 80 at the main engine to 825 at the generator pulley.

By this arrangement one can see that a difference of load on the main engine causes the speed of No. 1 to vary considerably. We don't mind this when only one machine is on the line. But when connected in parallel with No. 2, which receives its power from a Westinghouse engine through one belt, they cause lots of trouble. First one machine will have the load and then the other and for two hours they run so that someone has to stand close by the switchboard; we have no circuit-breakers.

The climax arrived with a new engineer, who knew all about running machines in parallel and who could not be shown anything about electricity. I am far from being an expert and I was glad we had got a good electrician at last.

When he came on duty I turned the job over to him, just telling him that when the load got so one machine could handle it, to cut out No. 2. As I turned around to get my coat, the new man grabbed No. 2 rheostat and gave it a twist, and the fireworks began. I jumped and pulled the main switch of No. 1 machine (*A* in the accompanying sketch), but the machine had come to a standstill; the 10-inch rubber belt that drove one of the countershafts had broken right across the hooks. I repaired the belt and started up and after getting the voltage up equal to that of No. 2 machine and closing the equalizer switch, I pushed in the main switch and almost broke the belt again, and melted the switch points badly.

By that time the load had lightened up, so I pulled out No. 2 and put No. 1 on the line. But I noticed the arc lights did not burn very brightly and some Cooper-Hewitt mercury lights we have would light up and then go out Still I did not know what the trouble was until I read over the instructions which came with those lights. Then I knew that the polarity was reversed.



WIRING DIAGRAM SHOWING CONNECTIONS OF THE TWO MACHINES

I chased up all the books and old periodicals I had and searched through them for some light on reversed polarity, but I either overlooked it or the writers all thought it was too simple a subject to discuss. Anyhow I could not find it. The man who knew it all was as far up a tree as I, so we sent for the chief, and this is what he did.

No. 2 machine was on the line so he took the brushes *B B* of No. 1 machine out of the holders, started the machine up, threw in the switch *A* for about a minute and pulled it out; then he put the brushes back in the holders of No. 1 and turned the rheostat around until the pilot light lit up, but the voltmeter did not register. Then he reversed the connections *a b* between the voltmeter and the generator leads, and the voltmeter registered all right.

When both voltmeters registered the same he closed the switch *A* and the machines were in parallel and running all right.

He told us to be careful in using one machine to restore the polarity of the other, because when pulling out the switch through which the reversing current is flowing an arc is formed which may set up a very high voltage in the field winding of the reversed machine and break down the insulation. Therefore, he thought it was safer to take the current off both machines before pulling out the connecting switch, and this should always be done if possible.

A. W. GRISWOLD.

Adams, Mass.

Eddy Current Detector

During the month of January, 1909, we had the misfortune of damaging a 2300-volt, 5500-kilowatt generator to the extent that 33 coils were burned and the laminations were a mass of copper and iron.

The armature core is of the slotted type with overhanging teeth, and we had considerable trouble in removing the copper from the slots; in some places it could not be removed with a tool, and therefore a large amount of acid was used. After removing all the visible copper, and repairing the armature winding we started up the machine. The result was that it broke down before half voltage was built up. The armature winding was removed entirely and dummy armature bars of wood were placed in the slots to show where the troublesome sections were. Upon starting up again, with the field excited and only the wooden bars in the slots, all the burned sections were located by the

charring of the blocks. Upon investigation, considerable copper, which had escaped detection before, was found between the laminations, short-circuiting them.

The wooden-bar scheme proved very successful but the length of time required to take down and reassemble the machine to be tested was about five hours, and the expense was large. Therefore, a device was made to test the armature laminations for short-circuits which would permit eddy currents to flow. The detail drawing of the "detector" is reproduced in Fig. 1, and the diagram of connections is shown by Fig. 2.

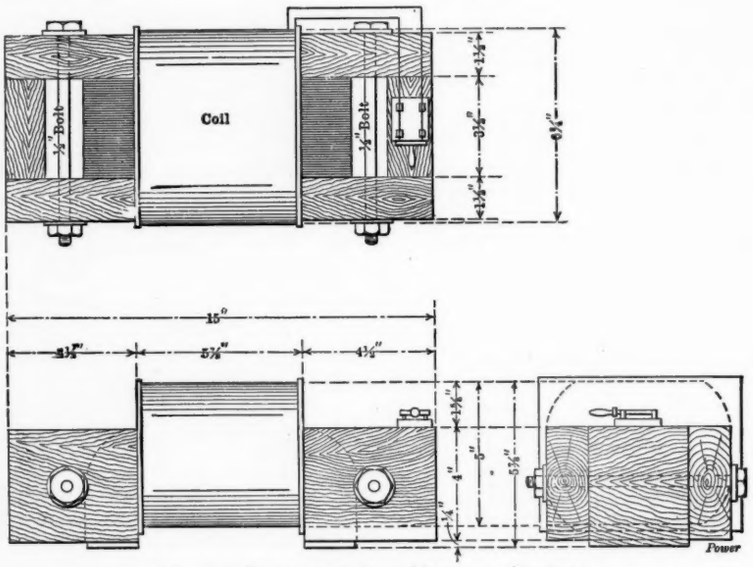


FIG. 1. PLAN AND SIDE VIEW OF DETECTOR

The detector is very simple, consisting of laminations taken from an old Stanley transformer of 500 watts capacity, built in a wooden frame and equipped with a coil containing 150 turns of No. 10 rubber-covered wire. Each end of the detector core was fitted to the curvature of the armature core. A voltmeter and a rheostat complete the equipment to be used in the test; a water rheostat is preferable. The object of the rheostat is to prevent an excessive current from flowing in the coil when a very bad section is tested.

In testing, the detector is applied first to a place where there is no trouble, and the voltmeter reading at this place is used to check by, and in adjusting the voltage.

Assume that the voltage is 110 volts at a clear spot. Move the detector to a burned or suspected section and close the little switch on the frame. If the section is bad, the eddy current in the laminations will cause a heavy current to flow in the coil and the indicated voltage will drop to a low value—sometimes to 10 or 15 volts. In less faulty sections it may drop back to 75 or 80 volts. If a drop of three volts from normal is obtained at any spot on the core, that place should be treated before putting armature coils in the slots there.

It is advisable to keep a record of all tests made, so that comparisons can be made when successive tests are made.

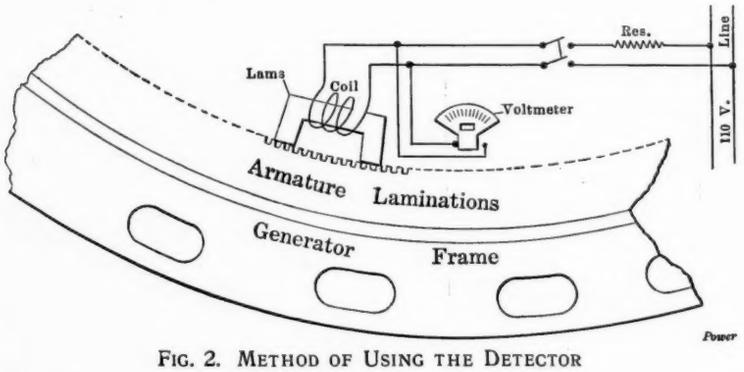


FIG. 2. METHOD OF USING THE DETECTOR

The detector here illustrated was made at our plant, and its cost was not more than five dollars. The detector can be applied to any machine by giving the ends of the core the proper curvature to fit the armature surface.

WELDY S. YEAGER.

Colgate, Cal.

A Queer Cure for a Balky Dynamo

One morning, a few days after I had taken charge of a plant that furnished three-phase current for power purposes, I had trouble in getting the 7½-kilowatt compound-wound exciter to build up. While I was trying to locate the trouble my fireman came to the engine-room door and seeing the difficulty came in. He took a small stick, sharpened it to a blunt point, put the point in the "center" of the armature shaft and pushed the revolving armature out of its central position between the poles toward the brushes. The result was that the machine came up to normal voltage in about half a minute. This "priming," as we called it, did the business many times afterward. It was only at starting that this was necessary; the stick was removed as soon as the voltage began to build up. The commutator and brushes were in good condition, and the brushes set staggered so as to cover nearly all of the commutator surface.

When asked why he did it, the fireman said that he had done it while he and the former engineer had been "fussing" with the exciter when it had balked on a previous occasion, and that he had had no reason for it.

I confess that I don't know the "answer" to this, and I hope that some POWER reader may enlighten me.

It might be well to add that about three months after this occurrence we had trouble with this machine sparking and heating, caused by high mica in the commutator. This was stopped by cutting out the mica about 1/32 inch below the surface of the commutator, with an old hack-saw blade.

DOW R. WALKER.

Chicago, Ill.

In order to concentrate magnetic-iron ore of from 35 to 40 per cent. iron from 50 to 60 per cent. metallic ore, the magnetic process is made use of to decided advantage. By this method no iron in lumps is obtained, but only fine granular magnetic ore. This fine-grained ore is of high percentage. Consequently it is rather wasteful to mingle the pure material with the lump ore of inferior quality, because either it is lost as blast dust, through the wind pressure in the high furnace, or on account of its dust-like form its quality deteriorates through the coke by the assimilation of sulphur, silicon and phosphorus.

Experiments which were recently made at the Worcester Polytechnic show that copper sheets which have been electro-deposited with copper possess much greater heat-transmission properties than ordinary copper sheets, which have not been so coated. It is suggested that this property may affect the design of condensers, radiators, etc.

GAS·POWER·DEPARTMENT

Everything worth while in the Gas Engine and Producer Industry will be treated here for the use of practical men

A Novel Type of Pump

A rather radical departure from the beaten track of pump construction has been made by H. A. Humphrey, a well known English engineer who has specialized in gas-engine work for several years. The pump is a sort of pulsometer in which the periodic pressure impulses are obtained by exploding a mixture of gas and air in the water chamber of the pump.

In diagrammatic form the general arrangement of the parts of this machine is shown in Fig. 1, for which we are indebted to *The Engineer*, of London. Considered broadly, the pump consists of a combustion chamber *C*, a valve chamber *W*, and a discharge pipe *D*. Around the wall of the valve chamber *W* are mounted several check valves *V* opening inwardly; the supply tank *G*, from which the water is to be pumped, is in communication with these valves by way of an annular passage surrounding the chamber. At the top of the conical combustion chamber *C* are two valves *a* and *e*, the former, which controls the gas supply, opening into a small pocket *q*, and the latter, controlling the port to the exhaust pipe, resting on a seat formed in the crown of the chamber at a level below that of the admission valve. A spark plug projects into the chamber *q*. There is also an automatic interlocking gear attached to the valves *a* and *e*, as illustrated in Fig. 2, the functions of which are described farther on.

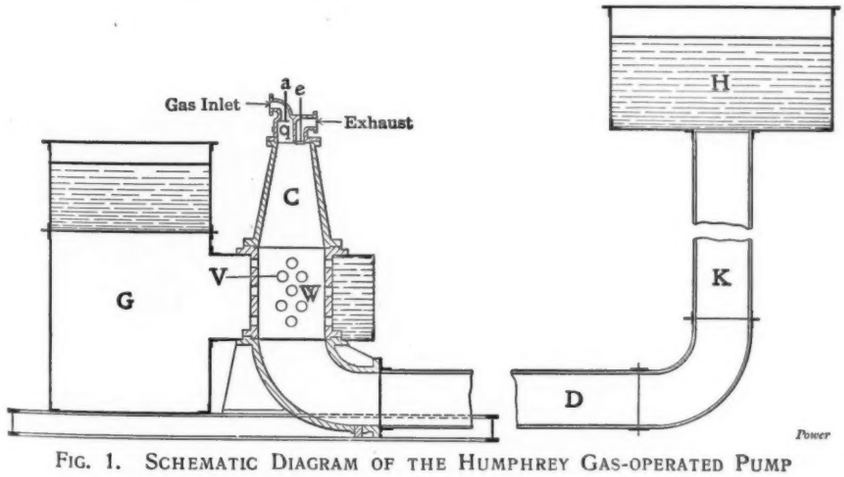


FIG. 1. SCHEMATIC DIAGRAM OF THE HUMPHREY GAS-OPERATED PUMP

To follow the process of operation, assume that the water is initially at rest, and at the same level in the tank *G*, the chamber *C*, and the upward bend of the discharge pipe *K*. Under these circumstances, suppose a charge of compressed gas and air to be introduced into the chamber *q* over the surface of the water and exploded. The resulting pressure on its surface drives the water along the pipe *D* and up the vertical pipe *K*, which leads to the point of discharge represented in the elementary diagram by the tank *H*. During this outward flow of the water the pressure within the chambers *C* and *W* falls, when the exhaust valve *e* opens the combustion chamber to atmospheric pressure. The same reduction of pressure also brings about a flow of water from the tank *G* through the valves *V* to the chamber *W*. This additional water joins the water initially present in the pump, and partakes of its further movements. When the kinetic energy of the outward flowing mass of water has become changed to potential energy, the water will reverse, and flow back along the pipe *D*, carrying with it the additional water taken in through the check valves, which close, of course, as soon as the inward flow of water from the tank *G* ceases. As the receding water rises within the chamber *C* it expels the products of combustion through the exhaust valve *e* until this valve is closed by the pressure of the water on its lower face.

There is now only a small portion of the burnt gases remaining in the combustion chamber, and this the rising water compresses within the pocket *f*. The pressure of this cushion of gas causes the water again to flow in the outward direction. For the second time, therefore, in the same cycle the pressure in *C* and *W* falls, but the water valves *V* do not open again, as the second outflow of water does not go sufficiently far to cause a reduction of pressure on the back of the valves great enough to allow them to open. This second reduction of pressure, however, causes the gas valve to open and admit a supply of fresh mixture to the combustion chamber. The velocity of discharge in this case is less than in the first, and the water soon returns, compressing the charge into the upper end of the chamber, whereupon the compressed charge is fired automatically and the second cycle is begun.

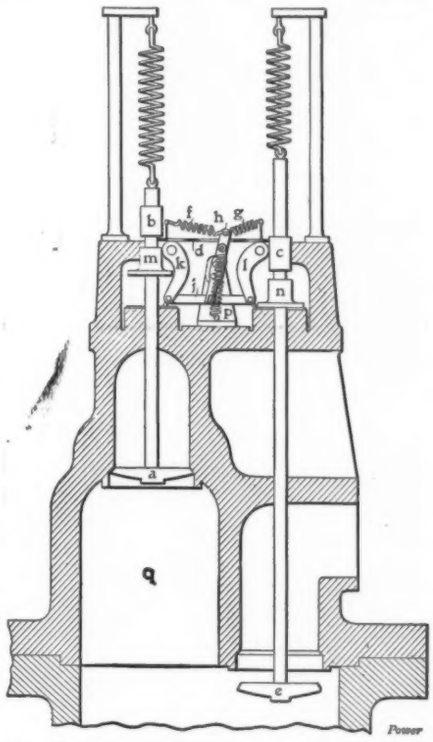


FIG. 2. INTERLOCKING-VALVE MECHANISM

It is obvious that the valves *a* and *e* require some form of locking device to cause them to open alternately when the reductions of pressure within the combustion chamber take place. It is for this purpose that the mechanism shown in Fig. 2 is provided. On each valve rod is a collar *b* and *c*, and beneath these the edges of the sliding plate *d* catch alternately. The movement of the plate *d* is controlled through the springs *f*, *g* by the lever *h*, which receives its motion from the bar *j* and pawls *k*, *l*. These pawls are in turn actuated respectively by the collars *m*, *n* on the valve rods.

In the position shown in the engraving, the gear is in the position for the exhaust "stroke." When the pressure of the water on the exhaust valve pushes

the valve rod up, the edge of the plate *d* slips beneath the collar *c*, by reason of the tension in the spring *f*. The suction "stroke" then taking place, the admission valve is free to descend, and in doing so causes the collar *m* to bear against the pawl *k*, thereby throwing the lever *h* over to the other side, where it is held by the spring *p*. No motion of the plate *d*, however, takes place during this period, as its edge is bearing against the collar *b*. The exhaust valve, therefore, remains locked until the admission-valve rod rises and allows the plate *d* to move over to the left, when the exhaust valve is set free and the admission valve locked again.

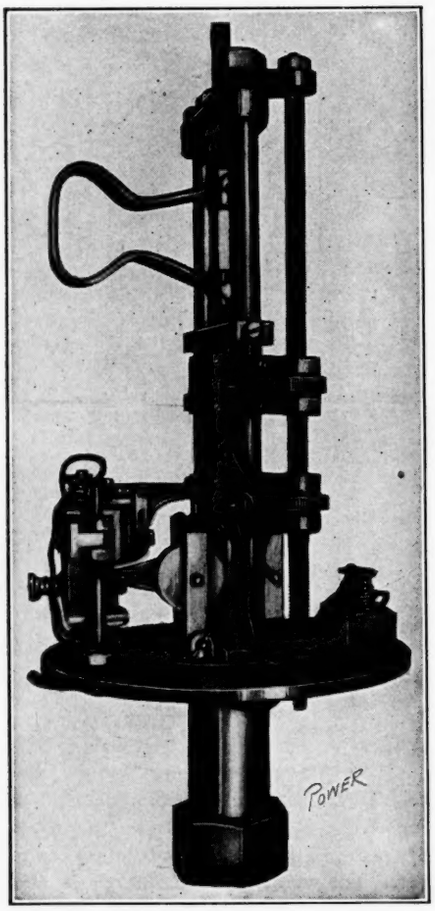


FIG. 3. AUTOMATIC IGNITER

The ignition apparatus is shown in Fig. 3. This consists of a piston moving in a cylinder which is in communication with the combustion chamber. The piston rod points upward, and is loaded at its upper end with the curved flat spring shown in the engraving. Two small pulleys bear against the piston rod, being held up to it by springs. On one of these pulleys is a small arm, the attachment between the two being, however, only due to friction. The motion of this arm is limited in amount by an upper and a lower stop. During the upward motion of the piston rod, that is, when the pressure within the combustion chamber of the pump is rising, the arm is pressed against the lower stop, but as soon as the pressure commences to fall the arm rises, making contact with the upper stop and giving a spark at the plug. With this apparatus the charge is ordinarily fired immediately after the compression pressure reaches its maximum value, as described, but the mechanism embodies other details which can be used if desired to give a spark at any predetermined pressure.

This remarkably simple device was tested a few months ago (before its construction was made public) by Prof. W. C. Unwin, using Mond producer gas for operating the pump. Table 1 gives the average values of the principal results of the tests. The pump was started by means of compressed air, and during the trials it worked at different hights of lift without any change in the gas and air proportions of the mixture or any alteration in the volume of the "cushion" pocket *q*.

TABLE 1. SUMMARY OF TESTS OF HUMPHREY GAS PUMP.

Lift Feet.	Pump Horse-power.	Mond Gas Used per P.H.P.-Hour, at 760 mm. and 0 Deg. C., Cu.Ft.	Calorific Value of Gas per Cu.Ft. in B.t.u.	Heat Expended per P.H.P.-Hour, B.t.u.	Lb. of Anthracite in Producer per P.H.P.-Hour.
32.87	16.15	83.12	147.3	12,243	1.063
25.95	12.32	90.93	143.5	13,037	1.132
20.73	10.99	93.61	145.3	13,596	1.180

At first sight it might be urged as an objection to the method of working that the water would become sensibly heated, but this, Professor Unwin says, is not so, as most of the heat of explosion disappears in the exhaust. In his trials the water was in continuous circulation through the pump, but in spite of this the temperature of the water in the storage tank did not rise 1 degree Centigrade during an hour. He states that the maximum lift apparently depends solely on the length of the discharge pipe, and that the pump works at lower lifts without any alteration and without any considerable change in its efficiency.

In criticizing the Humphrey gas pump on the results of these tests, Professor Unwin compares its performance with that of a gas engine driving a centrifugal pump of the same capacity. He states that under similar circumstances the gas-engine and centrifugal-pump installation would require from 120 to 127 cubic feet of gas per pump horsepower-hour, while the Humphrey gas pump requires 83.1 cubic feet. He also compares the new type of pump with some large steam-pumping engines of the highest class, and remarks that, although the steam sets had the advantage of a much greater lift, their economy did not approach that of the Humphrey pump. The pump horsepower of the three examples of steam sets mentioned ranged from 217 to 450, and the lift from 54 to 129 feet, while the coal consumed per pump horse-power-hour was 1.996, 1.622, 1.695 pounds respectively. In the case of the Humphrey pump tested, the lift was 32.9 feet and the pump horsepower 16.15, but the equivalent consumption of coal per pump horsepower-hour was only 1.06 pounds, a figure which Professor Unwin states is, as far as he is aware, unexcelled by any other pumping machine.

A Simple Bituminous Gas Producer

It is a source of considerable satisfaction to be able to point to a 100-horsepower suction-gas producer which has been in operation without repairs or adjustments 24 hours a day, six days out of the week, for over two years, gasifying Hocking valley bituminous coal costing $1.85 per ton delivered. The producer furnishes gas to the power plant of the Smith Gas Power Company, Lexington, Ohio, where the producer was made, and is shown in the accompanying illustrations. It is of the up-draft type and is unusually self-contained; the photographs show the complete apparatus necessary for generating, scrubbing and cleaning the gas, and delivering it to the engine ready for use.

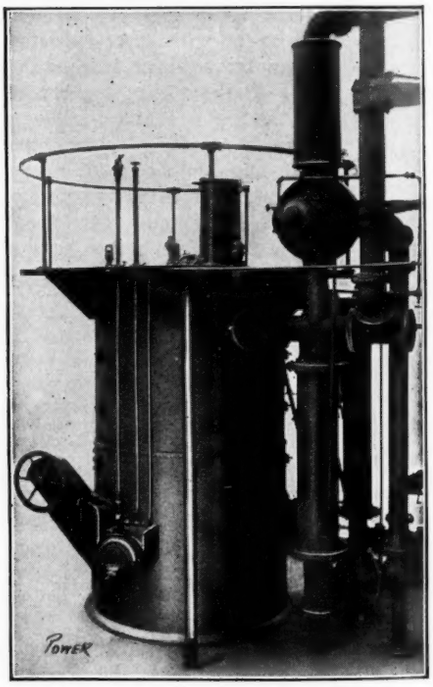


FIG. 1. SMITH PRODUCER

The conventional tower scrubber has been eliminated and a compact "baffle" scrubber has been substituted. This consists merely of a length of flanged pipe about 12 inches in diameter and 4 or 5 feet long, containing a series of cast-iron baffle plates, and depends for its effectiveness upon the forcible admixture of the gas with the scrubbing

water, which is thrown back and forth through the gas current in the form of a coarse spray. Here the gases fall from the generator outlet temperature to ordinary temperature, and the coarser impurities are removed through a water seal at the bottom.

The baffle scrubber is provided only for cooling the gas and removing the

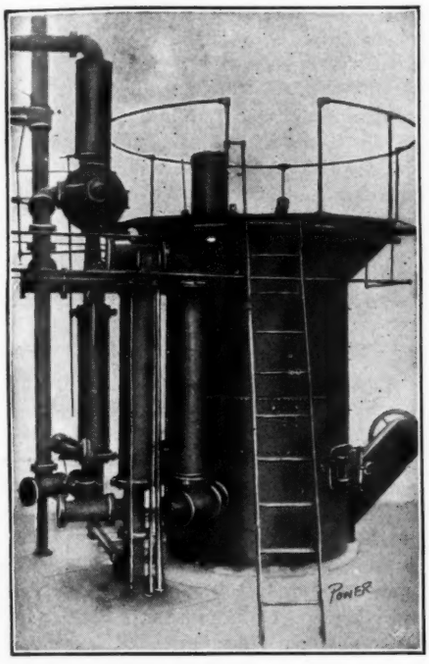


FIG. 2. SMITH PRODUCER

coarser impurities, not for any considerable cleansing of the gas. Impurities in the form of fine dust, tar or lampblack existing in the gas in an extremely minute state of subdivision are removed by being brought into violent contact with water in a mechanical scrubber located above the outlet, and mounted on a special cast-iron cross, as shown in the photographs. The effectiveness of the apparatus depends wholly upon the degree of violence with which the dust particles are brought in contact with the cleaning water.

This method of scrubbing has been worked out on the theory that the minute particles of impurities are covered with a coating of tarry matter, and until the surface tension of this coating material is broken up by mechanical means the particles will not mix with water, and therefore cannot be washed out. Centrifugal force is not depended on, except to throw the impurities away from the apparatus after the mixing has been accomplished.

The gas is passed through alternate sets of metal blades, revolving in opposite directions, and the particles of dust or other impurities are projected with great force from a series of vanes running rapidly in one direction against the next set running with equal speed in the opposite direction, the scrubbing effect being produced by this extremely rapid change in the velocity and direction of the gas current.

Where coal rich in tar is used and it is desired to reclaim the heat value of the tar, a special recovering device is placed in the overflow to the water seal. The tar thus collected is fed by gravity into the high-temperature zone of the fuel bed, where it is consumed, giving a notable increase in the efficiency of the producer.

The generator embodies some features worthy of special notice. It has a swinging grate supported by chains at three points, and is designed to distribute the draft over the whole area of fuel bed so as to prevent channeling next to the lining, where the interstices between the coal and the straight sides of the producer are materially larger than the interstices between the particles of fuel in the body of the bed. The grate is divided into an inner and outer ring and is arranged so that either part may be shaken separately, or both together. The shaking is done by a double-acting air cylinder on the outside of the shell, shown in Fig. 1. The valve stems for controlling the mechanical shaker extend upward to the operating platform, making it possible to attend to the fuel bed from the one position.

A fuel-bed depth of not less than 5 feet is maintained in the generator and in addition to this the fuel magazine extends at least 3 feet farther, making a total depth of not less than 8 feet. By reason of this arrangement the coal lying immediately above the active part of the fire becomes red hot simply by contact with the outgoing gases, the layers of the fuel higher up absorb still more heat, and when the gas finally reaches the outlet from the producer a very large percentage of the sensible heat has been withdrawn from it and returned to the fuel. This heat is, of course, carried into the active part of the fuel bed as the coal descends from above.

Charging of fuel is accomplished in a slightly unusual manner. Around the top of the generator, between the center and the shell, are three charging holes, and there is a portable hopper which may be clamped to any of them. A central sleeve having a water-cooled tip extends down to the active part of the fuel bed and it is around the outside of this that the fresh fuel is charged. Gas is drawn off through this central chamber.

Instead of using the heat of the outgoing gases to vaporize water for the producer, as is the ordinary custom, the waste heat from the gas engine is used for this purpose. With this system a small special tubular heater is placed in the engine exhaust pipe and the jacket water is discharged into this heater, where it is raised to a fairly high temperature for delivery to the generator. At the generator this supply of hot water passes through a distributing device which is under the control of a thermostat located in the air line leading to the producer ashpit. The regulation depends on the principle that air of a given temperature will carry in suspension a fixed amount of moisture and no more. The distributor throws a certain definite part of the supply into the upper part of a baffle saturator which brings the hot water into intimate contact with the air as it is passing toward the producer, and it accordingly picks up as much vapor from the hot water as it can possibly carry; in other words it becomes saturated for its temperature. After passing the saturator this moist air passes over the thermostat which controls the distributing device.

Natural Gas in Hungary

The first important discovery of natural gas in Europe is reported from Kis-Sarmas, in the district of Klausenburg, in Hungary. Its presence first became known two years ago when shepherd boys used to light the vapors rising from the marshes.

Upon a geologist's report the ministry of finance directed borings to be made, when large quantities of gas were discovered at a depth of 60 feet. The borings were continued to a depth of 600 feet, when the gas was found in such volume that big stones were thrown into the air by it. At the present time the gas is flowing out of a pipe with a noise that can be heard six miles away. The flow is estimated at 6,000,000 cubic feet per 24 hours.

Analysis shows that it is a peculiarly clear methane gas, containing scarcely ½ per cent. of nitrogen. Upon the advice of experts the Hungarian ministry of finance has bought the gas-mining rights for $21,000. It is proposed to utilize the gas supply in running a large central electrical plant to be built on the ground.

The city of Austin, Tex., used to have a large lake, formed by a huge dam built across the Colorado river. This dam was 1275 feet long and 67 feet high above bedrock. A plant placed just below the dam converted the water power into electricity, which was used for lighting the city and operating the street railways, as well as for a number of industrial plants. In 1900 the dam and power plant were washed away by a flood, and the city was too crippled to replace them. A movement is on foot now to rebuild this dam, making it of reinforced concrete. The power obtainable will probably attract many manufacturing industries, which would undoubtedly contribute materially to the development and growth of the city.

CORRESPONDENCE

Uneven Wear of Gas Engine Piston Rods

In a large mill engine near here the same annoyance was experienced as that described by L. B. Lent in the December 7 issue of POWER. In this case the water was piped to the crosshead and thence flowed freely along the bore of the hollow piston rod to the tail rod, circulating through the pistons on its way. Abnormal wear was experienced on the front piston rod. The cause of the trouble was finally ascribed to the formation of sulphurous acid on the cool rod. The water discharged from the end of the tail rod into a sump whence it was pumped, with the jacket water, to a roof tank. The wear of the rods was almost completely cured by leading the water from the crosshead to the front piston jacket and thence to the rear piston jacket, by a pipe inside the hollow piston rods, and returning it through another pipe going clear through the pistons and lying alongside the admission pipe in the bore of the rods. Luckily the rod diameter was just enough to take the two pipes side by side. The temperature was thus evened up along the rod and the wear was greatly diminished. If Mr. Lent could adapt this method to his engine I think he would get the desired results. If the bore of the rods is too small to allow two pipes of sufficient size to be passed through, I would suggest feeding through a pipe placed centrally in the bore and returning the hot water to the crosshead outlet free in the bore and surrounding the pipe. This should be even more effective than the two-pipe method from the viewpoint of curing wear.

JOHN S. LEESE.

Manchester, Eng.

Gas Engine Cooling Water

The article in a recent issue by H. W. Jones, on the above subject, causes me to compare my experience with his. I once ran a 300-horsepower, three-cylinder, vertical gas engine, the water jacket of which extended 2 inches below the top ring of the piston when on the lower center. It was impossible to run the jacket-water discharge on this engine up to 150 degrees Fahrenheit at full load; if we did we had a hot piston in a very short time. The engine was of the splash-lubrication type, and oil thrown on the piston would bake or become carbonized, shutting off lubrication to the cylinder walls. Besides this, the metal from the piston would draw over the piston-ring grooves, holding the rings solid and causing the piston to leak and throw oil, which would become carbonized in the compression space; small balls of carbonized oil would bake to the cylinder head and become red hot, causing premature ignition and back firing. The small amount of gas saved by running the jacket water hot would hardly pay for the labor in keeping this engine in repair nor for the oil burned up in the engine.

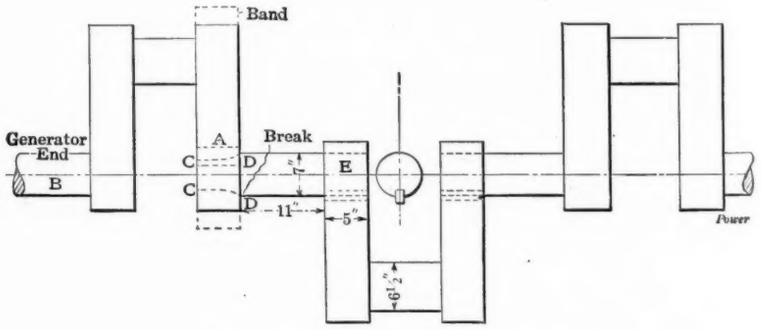
My experience is that there are very few gas engines that give the same results under the same conditions. Two engines of the same design set up in the same power plant and given the same attention will give altogether different results. Therefore, each engine must be studied out and its peculiarities found out in order to handle it to the best advantage. Whether the water jackets be long, short or medium, the water should discharge at a temperature to suit the engine and its running conditions. As far as "Quit your kicking" is concerned, I would like to hear a little more.

T. W. ALLMAN, JR.

Swissvale, Penn.

Repairing a Gas Engine Crank Shaft

I have just finished testing out a repair which I believe will be interesting to any engineer who has had crankshaft troubles. I have in my charge a three-cylinder Westinghouse gas engine, 16x18 inches, running on producer gas and developing about 175 horsepower. This engine is direct connected to a 125-kilowatt generator and runs at 240 revolutions per minute.



REPAIRING A BROKEN CRANK SHAFT

About two months ago the crank shaft broke, as shown in the accompanying sketch. This shaft is built up, the middle crank being forged in one piece and keyed onto the shaft portions of the two end cranks. In repairing the shaft it was placed in the lathe with a steady rest at *B* and the crank cheek *A* was bored out with a flare, as indicated by the dotted lines *C D*, and keyseated for keying to a new intermediate piece of shaft. The broken stub was removed from the crank cheek *E* and a new piece turned of tool steel to replace the broken one. The keys were fitted in the short shaft and the crank cheeks were shrunk onto the ends of it.

The middle crank was originally heavier than the end one so it was strong enough, but the other crank, being too light, was reinforced by a soft-steel band 2 inches thick by 5 inches wide and this was machined on the inside, allowing 1/16 inch endwise and 1/32 inch sidewise for shrinkage. The location of the band is indicated by the dotted lines on the ends of the crank cheek *A*.

This shaft was put into service within 48 hours after the engine was shut down, and everything has been going satisfactorily ever since. The shaft seems as true and as strong as ever.

F. N. BIERCE.

Alexandria, Ind.

Pre-ignition Due to a Bad Gasket

F. H. Fielding's article on pre-ignition trouble in the January 4 issue reminds me of an experience with a small vertical gasolene engine, belt connected to a geared pump and used about nine months of the year. One spring there was trouble at times from pre-ignition, and as I had not had much experience with gasolene engines I could not determine the cause. One morning the engine slowed down and stopped. Upon cranking I found all compression gone. I took the cylinder head off, expecting to find a broken valve, but both valves were in good condition and also the piston and rings. I noticed, however, that the asbestos gasket on the cylinder head was rough and frayed on the inner edge. A new gasket was put in after being soaked in linseed oil and drained, care being taken to have the inner edge smooth. After the cylinder head was put back on, the engine was started and ran the rest of the year without trouble.

It is probable that the frayed edge of the gasket formed a convenient place for the lodgement of carbon which became red-hot and continued to glow during the admission and compression strokes.

ARTHUR E. OAKLEY.

Bedford, N. Y.

From READERS *with* SOMETHING *to* SAY

Practical information from men on the job—A letter good enough to print is good enough to pay for.

Faulty Drain Systems

There is an error made daily by designing and constructing engineers, the error of using a steam trap that is too small. Most any trap has sufficient capacity when it has ample time, but

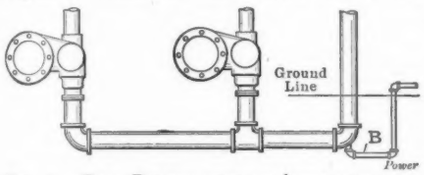


FIG. 1. BAD DRAIN-PIPING ARRANGEMENT

steam-pipe lines leading to high-speed direct-connected engines, should have steam traps of larger capacity than are ordinarily used. This type of engine will not stand a dose of water; it usually proves fatal to the engine when water is carried to the cylinder. If a trap of ample capacity for emergency is used, it will easily take care of the line under normal conditions.

A steam separator, which really only amounts to a condenser, is frequently found close to the throttle, causing an extra amount of condensation, due to the fact that it is much too large; as much too large as the trap is too small. Too much surface in a steam separator is dangerous as well as wasteful of fuel. Yet numbers of excessively large separators are installed in steam lines, only to cause an extra burden for a trap of insufficient capacity and poor design. And such arrangements are depended upon as safety devices for the engines. When there is no steam separator and no trap, a blowoff line is tapped in just above the throttle and the line is blown out thoroughly before starting. Until dry steam can be seen coming from the discharge of this hand drain line, the engine is not started.

If traps were selected several sizes larger than is supposed to be necessary, many wrecks would be avoided, as the increased capacity would take care of an immediate rush of water and allow the trap time to discharge the surplus. Many traps are top draining; a bad feature at best, and something like the drain piping found in some power plants. When we are asked to make a good drain, we always look for a low point and do not select the top of a pipe as the place to tap the drain. Fig. 1 shows an example of a faulty drain system in a modern plant. Two engines of the piston-valve type, 14x14-inch and 10x14-inch, respectively, exhaust into the same line. The exhaust is drained, as shown by pipe *B*. It does not seem possible that anyone would install such work, yet it is being done right along.

In Fig. 2 is shown a form of disk relief valve for engine cylinders. When water is caught in the cylinder, the thin disk is supposed to give away and allow the water to escape. Referring to Fig. 2, we have a 1-inch pipe leading from the relief valve into the cylinder. The piston head runs past the opening of the pipe and leaves only a small space for the water to escape through. Besides, the diameter of the pipe is so small that the water would not pass through rapidly enough to relieve much of the shock to the cylinder head. If water was as elastic as steam, this type of relief valve would prove a more effective device. Of a number of actual experiences with this valve, on no occasion have I seen it work when put to the test.

Water pockets, poorly drained exhaust lines, and an excuse for a steam trap make some of the dangerous conditions we find about power plants. Dependence upon such futile safety devices often result in fatal accidents. Where we have a separator in the steam line it should

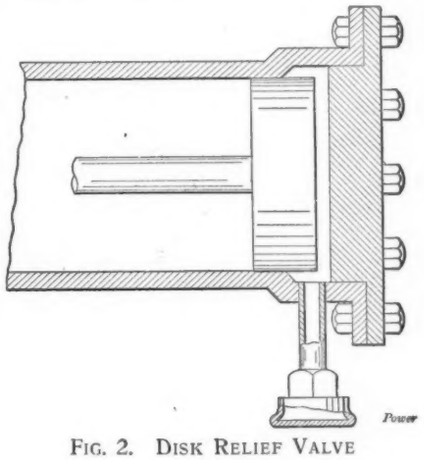


FIG. 2. DISK RELIEF VALVE

by all means be covered, even though the steam line remains uncovered. The line from the steam separator to the steam trap should be made larger than it is usually found. There are many long lines draining to a steam trap through only a ½-inch pipe. Such a condition alone will often prevent the proper working of the trap. Bad practice as herein described is more frequently found about the small power plant, but we find it, now and again, in the large ones.

C. R. MCGAHEY.

Richmond, Va.

Elevator Hand Rope Repair

We have a large platform freight elevator and in descending one day the hand rope caught and broke. The hand rope has no tension weight but is tightened by a turn buckle and runs over

LINK MADE FROM PIECE OF PIPE

stationary sheaves. The rope broke about 14 feet from the turn buckle and not on the stop-ball side. None of us being able to splice wire rope, and it meaning a shutdown of the whole factory if we waited to have a new rope put in, we had to make a quick repair. We tried a patent wire-rope coupling but found the rope would be too short.

We cut a piece of ½-inch pipe about 9 inches long, heated it in the boiler furnace and hammered each end so that the rope would just fit snug. Then we cut out half the circumference of the pipe about 1½ inches from each end, put the ends of the rope through, turned the strands over, and run in some babbitt which prevented the ends from pulling out. This made a neat, strong job and the elevator is running yet. An arrangement like this makes a good wire-rope coupling, and there is no reason why a coupling 10 feet long cannot be used if desired. This idea can be applied to other than elevator work with just as good success.

HAROLD JAMES.

Bayonne, N. J.

Is this Relief Valve Arranged Right?

I would like to have the readers of POWER give their opinion of the following relief-valve arrangement:

Three cross-compound, condensing engines carrying 155 pounds pressure and about 22 inches of vacuum, exhaust into one condenser. All the cylinders have relief valves on both ends. The valves are all piped to the exhaust of the cylinder upon which they are located. Thus the high-pressure cylinder, relief valves release into the receiver and the valves on the low side release to the exhaust. All are angle valves.

With valves piped like this, how do we know whether the valves are set right, and how can we tell if they are leaking? Is this the right way for relief valves to be piped?

This plant has been in operation about nine years and the valve arrangement is the same as originally planned.

JOHN J. KAYCE.

Alsen, N. Y.

Ignorance and Cupidity

An illustration of the extreme ignorance occasionally encountered is given in the following incident:

The engineer was engaged in packing the valve stem of a slide-valve engine of possibly 65 horsepower. My friend asked him how much steam it took to operate the engine with the load it was carrying, meaning, of course, the number of pounds pressure per square inch. The engineer looked up and then at the crank-pin brasses and with a tug at the connecting rod answered: "It takes about 200 pounds and it simply sets her brasses afire to do it, too."

I was surprised that so much pressure was being carried by the boilers, as they were of the common tubular type, such as are generally built for 100 pounds, steam pressure. My bewilderment did not last but a minute however, for then I saw his method of reasoning; it was simply,

$$1 + 1 = 2$$

The boiler gages were indicating 95 pounds each. "Oh," yes, I see," said I, "there are two boilers, 95 pounds each, twice 95 makes your pressure 190—almost 200 pounds."

"Yes, that's it. We have both boilers hooked to this engine," he said.

Is it safe to intrust such men with the care and operation of a plant of this kind? That they get along as well as they do, is a profound puzzle.

On another occasion, I was helping the engineer of a small plant install some machinery. We were hooking up a 1½-inch boiler-feed line. The engineer, after picking up the swinging check valve we were going to place in the line, and turning it end for end for five minutes in an endeavor to decide which end to place toward the boiler, asked me to take it over to the vise and open it to find out. Of course, outside appearances would have indicated which way to turn it, but to satisfy him, I placed the boiler end against my lips and puffed out my cheeks, then handed it back saying, "That is the end to go toward the boiler."

Now this man was a good, careful operator. But it is easy to see that he knew very little about the construction and operation of such a simple device as the check valve.

The only way to rid the profession of men whose lack of knowledge is a positive peril to themselves, and in many cases to others as well, is to enact rigid license laws. And let them be of Federal origin. Then the man who takes out his license in Massachusetts will be competent to operate in Arkansas and *vice versa*.

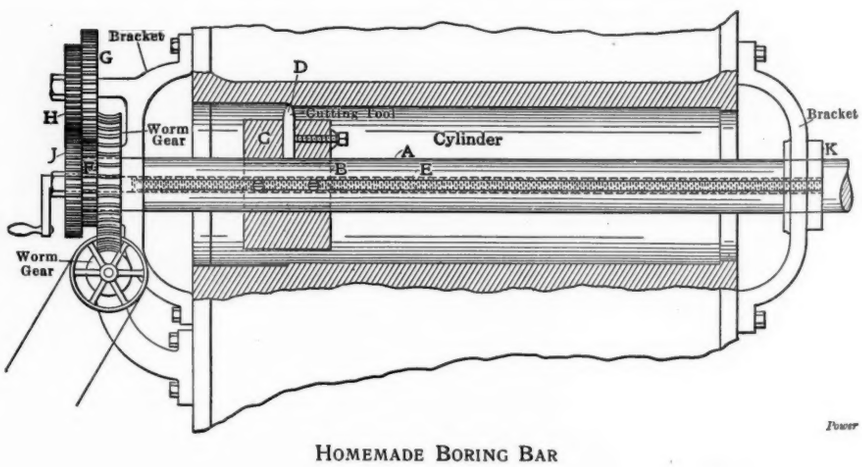
And while we are enacting Federal license laws let us also enact Federal boiler-inspection laws. There is need of them. Hardly a week goes by but the technical prints contain an account of some boiler-explosion disaster which involves loss of human life in addition to the monetary loss. Human nature is such that we will never learn that it is better, and cheaper too, in the long run, to be safe than sorry. And so we continue to buy apparatus built to sell on price alone; and to operate it until the day before we guess it will fail, which generally proves to be the day after; and to hire the cheapest help, which usually means men with the poorest mental equipment, until we become a victim of our own cupidity.

LLOYD V. BEETS.

Nashville, Tenn.

Homemade Boring Bar

In my plant I have a 12x28-inch Corliss engine, the valves of which were badly worn, as were also the valve chambers, which of course leaked steam. The engine is run 12 hours every day, excepting Tuesday. As I have a lathe, planer, and drill press at my plant, I decided to make a boring bar and tackle the job of reboring the valve chambers and making new valves for the new bore. The boring bar was made as shown in the illustration.



HOMEMADE BORING BAR

I took a piece of 2-inch extra-heavy pipe *A* and turned it off smooth on the outside. A piece of brass *B*, 3 inches long, was made a loose fit inside of the 2-inch pipe to travel easily from end to end, and through the center a hole was bored and tapped with a ½-inch No. 13 thread. Next, a cutter head *C* was made of cast iron and bored out for a snug sliding fit over the piece of pipe or bar. This cutter head was 3 inches long, the same as the internal brass nut *B*. A ⅜-inch hole was bored in this head and a tool-steel cutter *D* fastened in place with a small set screw. The bar *A* has a slot ½ inch wide running lengthwise up to within 4 inches of each end. The cutter head and the brass internal nut were fastened together through this slot, so then when the bar turned the cutter head, the internal nut turned with the bar.

I next made a pattern for two brackets of cast iron to be bolted to the cylinder in place of the bonnet, the brackets to hold the boring bar in place. On the outside of the brackets, on the bar, a small worm gear was put, and underneath on another bracket, a worm, which also had a pulley on the same shaft. This pulley was driven from a small engine, which turned the worm, worm gear, bar and also the cutter head. I then took a piece of ½-inch round stock, put a thread almost the whole length of it and this was put in the brass nut inside of the bar, as at *E*.

On the bar, outside of the worm gear, and fastened to it, a small spur gear *F* was placed, with 45 teeth, and on a stud above this was another gear *G* with 50 teeth, and fastened to it and revolving with it another gear *H*, having 45 teeth, and lastly a gear *J*, with 50 teeth, which was fastened on the ½-inch threaded rod *E*, which feeds the cutter head.

This bar can be run either way and makes a nice, clean, smooth cut. By putting the gear *J* on with a key and a nut on the outside, the nut can be taken off, the gear removed and a small crank put on in order to rapidly move the tool back and forth by hand when setting the tool.

On the other end of the bar I put a collar *K*, to run against the back bracket. The counterbores were also bored with this bar by setting the cutter out. When I had the bar completed I made patterns for the steam and exhaust valves and had them cast. I then bored out one valve chamber, and made the new valve a snug fit in the bore, cut the slot for the stem and started up next morning;

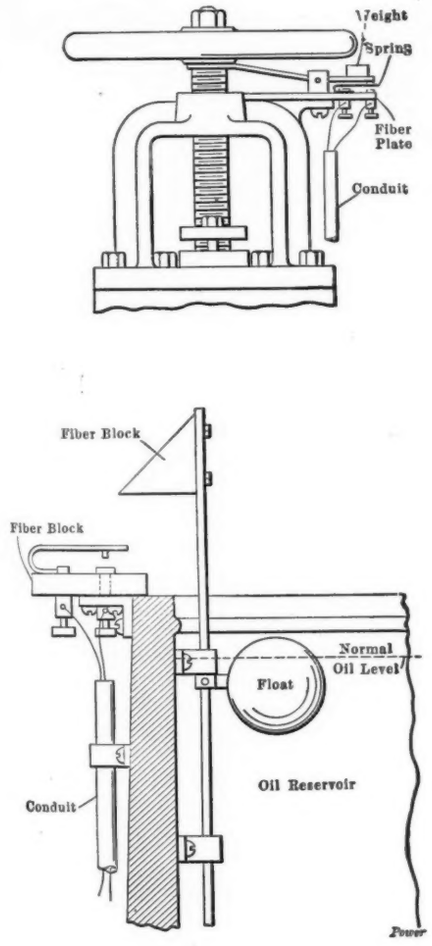
taking one valve at a time, until I had all four done. I also took out the crank shaft and sent it to a machine shop that had a large lathe, had the bearings turned, put it in again, babbitted the bearings all around, made new studs and pins for valve gear, new rings for the piston, and the engine is almost as good as new.

JOHN MORLOCK.

Brooklyn, N. Y.

Turbine Oil Alarm

It was a source of worry to the engineer in charge of a power station containing two 2000-kilowatt Parsons turbines lest the oil system should fail. The oil was circulated by a geared pump driven from the main shaft of the turbine. The reservoir held only two or three minutes' supply, and if the geared pump should fail, the most attentive operator might not observe it in time to prevent damage.



TURBINE OIL ALARM

An electrical alarm system operated by a float in the reservoir suggested itself, but any ordinary electrical alarm would require that a switch be installed so that the alarm would not ring while the turbine was stopped, as it was impracticable to maintain the reservoir full of oil at such times. A switch was considered undesirable in such an installation, for it was certain that it would be forgotten at some time and render the alarm system useless.

The throttle valves on the turbines were of the globe type with inside bypass, the stems making about two turns before starting the main valve. The threads on the stems were about six to the inch; this moved the hub of the wheel something over a quarter of an inch before enough steam was admitted to cause the turbine to revolve. Advantage was taken of this feature to render the switch automatic in its operation, by placing a pivoted arm in such a position that the hub of the throttle wheel would bear upon it when the throttle was closed, allowing a set of spring contacts to separate, as shown in the accompanying sketch. For each installation a copper ball float was secured to a light vertical bar which was set in guides inside of the reservoir with a fiber block attached to the upper end of the bar, protruding through the top of the reservoir. When the reservoir was full of oil, the float and connecting bar raised the block from the contacts, allowing them to separate, while if the oil lowered a certain distance in the reservoir, the float allowed the block to descend and force the contacts together.

A twelve-inch electric bell was installed in the circuit, energized by an independent battery of dry cells, and in two years' time it warned the attendants of three cases of oil shortage. An addition could be made to this system whereby the current which rings the bell when the oil supply becomes low would also open the throttle on the steam-driven auxiliary oil pump, but in this instance the space about the turbines was so limited that it was thought best not to apply it as there was always an attendant within hearing of the bell.

H. R. MASON.

Cape Girardeau, Mo.

Responsibility of Engineer

On November 1 an explosion occurred in a steam plant near this city. One man lost his life and considerable damage was done to the plant. On the 10-inch steam main was a 10-inch screwed tee one opening of which was bushed to 8 inches. This tee had been giving trouble by leaking and on the day in question the master mechanic ordered a workman to calk it. The man had struck but a few blows when the fitting burst, scalding the man and throwing him to the floor a distance of 20 feet.

The engineer's license was revoked by the State inspector although he was in no way to blame for the accident. The master mechanic should have been held responsible for he was the one who ordered the man to calk the leak and without the knowledge of the engineer.

It seems that the engineer is always held responsible whenever any such accident happens although he may not even be on the premises at the time.

O. M. DOWNEY.

Lowell, Mass.

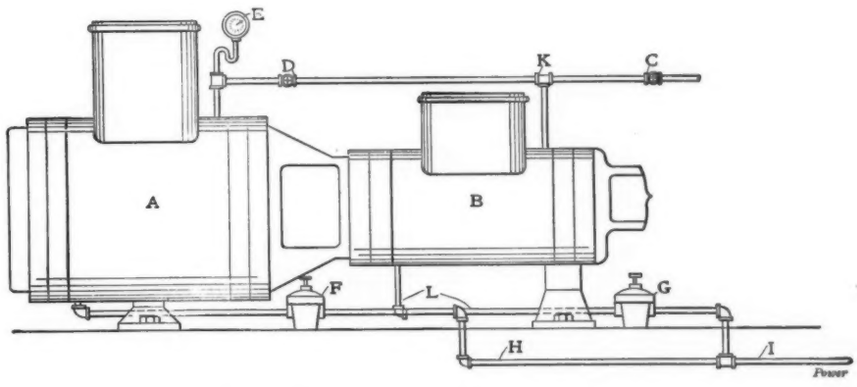
Advantageous Trap Alterations

An engineer friend asked me what style of trap I would use to drain the steam jackets of an engine cylinder. I replied that of the two types, the expansion and the float-valve, the latter has given me the better satisfaction.

He then asked me to show him a good drain layout for the jackets of the intermediate- and low-pressure cylinders of two triple-expansion, tandem, duplex, direct-pressure, pumping engines of three million gallons capacity each.

Steam was supplied to the jackets from the main header. It entered the intermediate cylinder at the top and passed out at the bottom, thence to the top of the low-pressure cylinder and out at the bottom to an expansion trap on the floor. This arrangement was not giving satisfaction.

The figure shows the arrangement I



ARRANGEMENT OF DRAIN PIPING AND TRAPS

suggested. Steam for the jacket of the intermediate cylinder is taken from the supply line at *K*. The drain outlet is through the pipe *L* and trap *G* to the line *I*. Steam for the jacket of the low-pressure cylinder is also taken off at *K*. The drain is through trap *F* and pipe *H* to *I*.

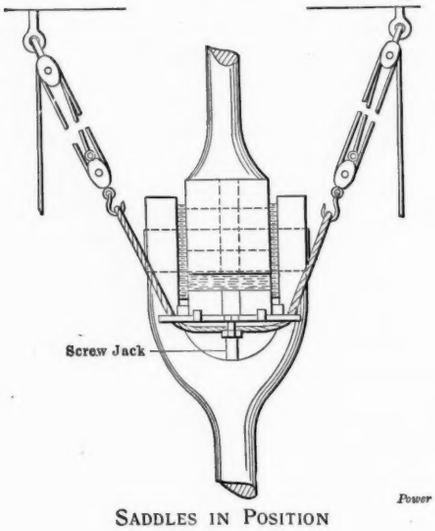
The valve *D* regulates the pressure of steam in the low-pressure jacket. Gage *E* indicates the pressure in the low-pressure cylinder jacket, and is necessary for two reasons. The pressure in the low-pressure cylinder is not greater than two pounds to the square inch; hence, it is not necessary to carry more than five pounds pressure in the jacket to maintain the temperature necessary to prevent condensation. The drains are received by an open heater which at times has five pounds back pressure. Hence, seven pounds pressure is carried in the jacket to prevent backing up from the trap.

C. W. DUNLAP.

Depew, N. Y.

"Taking the Leads" of a Vertical Engine

An easy method of "taking the leads" of a vertical engine with a forked-end connecting-rod type of crosshead is described herewith. The usual method of keeping one of the bolts in place as a guide and using a crowbar and blocks of wood necessitates shifting the bight of the bar, which invariably shifts the liners, thus making a bad job. By the aid of two cradles, placed in front and in back of the connecting rod, a screw jack and two pairs of tackle blocks, all danger of



SADDLES IN POSITION

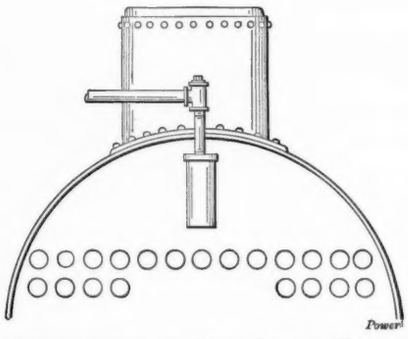
a bad job is removed. The cradles are made of ⅞x6-inch boards, about 8 inches longer than the cap is wide. Suitable stop pieces are fitted as shown to keep the cover from slipping. An endless rope is run through the four holes and under the bottom of each cradle. By having an endless and pliable rope the cover adjusts itself to a central position, should one set of blocks be pulled more than the other. The jack can very easily be made with a ⅞-inch bolt and nut inside of a piece of 1-inch piping. The engine is placed on the crank-end center and the jack put in position as shown in the drawing. Both bolts can then be removed so as to make room for the cradle. One end of each set of blocks can then be hung to the eye bolts that are generally under the cylinders for the purpose of lifting the caps of the main bearings, and the other end hooked to the rope of each cradle. The strain can then be taken by the blocks, the jack removed and the cover and bottom box lowered as gently as necessary. When the liners are adjusted the blocks lift the cover to position again, the jack is placed in position and the cradles removed to make room for the bolts.

HUGH R. MCCURTAIN.

Dorchester, Mass.

Boiler Feed Piping

The boilers of which I have charge were fitted with 1¼-inch feed pipes entering through the front heads. The portion of pipe projecting into the boiler was of brass, 8 feet long, capped on the end, and had three rows of ¼-inch holes extending the full length. The holes soon filled with lime. The pipe was removed and an iron pipe put in running nearly to the back head, then crossing over and emptying downward between the tubes and shell. After using this pipe a short time it filled up also and had to be removed. I then installed a 1½-inch iron pipe, 8 feet long and open at the end. This was a slight improvement over the other methods, but not entirely satisfactory.



ARRANGEMENT OF FEED PIPING WHICH PROVED SATISFACTORY

Finally, I removed the pipe from the bottom of the boiler entirely and plugged up the hole. Then I cut a long thread on a piece of 1¼-inch pipe and inserted the pipe in the top of the boiler, so that it projected through for 2 inches, tapped a 4-inch cap and screwed it onto the end of the 1¼-inch pipe. Then I screwed into the cap a piece of 4-inch pipe long enough to extend within 2 inches of the top row of tubes. This arrangement has given good service, with the exception that scale forms in the end of the 1¼-inch pipe between the shell and cap. To get at this scale I arranged a tee as shown in the figure. It is an easy matter to take out the plug and poke the pipe clear with a rod. The pipe needs to be cleaned only about once in three months. I have used this arrangement for seventeen years, during which time it has given excellent satisfaction. It has the approval of the boiler inspector.

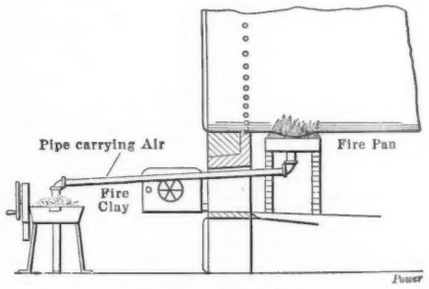
A. W. WILSON.

Sterling, Ill.

Driving up a Bag

A return-tubular boiler became bagged, and the following tells how it was driven up:

I had the bottom of an old stove that I used for my fire, and took a hand forge and set it outside in front of the boiler; then I ran a pipe from the forge to the stove fire box under the boiler. Fire clay was used to pack around the pipe where it connected to the forge, so



BLOWING THE FIRE

as to send the blast of air to the fire under the boiler without leakage. The handhole plate was removed so as to see inside the boiler.

When the plate was hot we worked a sledge, giving light blows and using a "flatter" next to the shell; the bag was then worked around and down at the same time. In this way we got the bag back in fine shape and no hammer used directly on it.

Never hit a bag directly on the bottom when real hot, as it will kink it. I have used this method for 20 years and can say that all the bags I have put back were pronounced a success by the boiler inspectors.

C. T. PERRY.

Oil City, Penn.

The average serviceable life of a locomotive in Great Britain is variously estimated at from 20 to 30 years. The annual expenditure per engine for renewals and repairs closely approximate $1150.

SUBJECTS UNDER DISCUSSION

Comment, criticism and debate upon various articles, letters and editorials which have appeared in previous issues

Transmission and Recording Dynamometer

In the issue of December 21 there appeared an article by Mr. Hughes describing his dynamometer. I have no wish to criticize this apparatus, which, I am sure, is an admirable one. But I do feel it incumbent upon me, as an able-bodied engineer, to hasten to the defense of my old friend, the prony brake. Mr. Hughes gives a plausible, but not convincing, demonstration by which he proves to his own satisfaction that this device has for

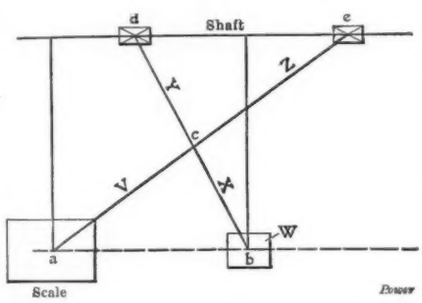


DIAGRAM OF PRINCIPLE OF BRAKE DYNAMOMETER

many years basely deceived those who have placed their confidence in it. It is curious that its duplicity has never before been uncovered, but let that consideration pass.

The fault in Mr. Hughes' argument is that in the torque of a motor he has an altogether different case from that of his demonstration. He shows a single weight acting on an arm attached to a shaft. The force which makes the torque of a motor, or a steam engine, is not a single one. Considering a steam engine, for example, the force applied to the crank pin is, of course, variable, being a combination of the steam pressure and the inertia forces of the reciprocating parts. It is the function of the flywheel to make the force uniform. The resulting torque may be considered to be made up of a number of inertia forces, created by the moving weight of the flywheel, acting tangentially to it. On one side of the flywheel, looking at the shaft endwise, these tangential forces are moving down; on the other side they are moving up. We can, therefore, substitute for these torque forces two equal and opposite forces, acting tangentially to the flywheel, one down one side and the other up on the opposite side. Under no circumstances could they be substituted by a single force, as Mr. Hughes' weight signifies.

Mr. Hughes seems to have some faint suspicion of this himself for he says, "An equal upward pull on the opposite side of the shaft might tend to balance the error." But he brushes this consideration aside by adding: "or it might tend to make matters worse."

The fact of the matter is there is no other way of considering torque except as two equal and opposite, parallel forces. Anyone having the slightest knowledge of mechanics knows that this combination is a "couple" and that a couple cannot possibly be balanced or replaced by a single force. If Mr. Hughes will turn to page 22 of Rankine's "Mechanics" he will see that "two couples applied to the same body in parallel planes, and equal in force and leverage, but opposite in direction, balance each other; and if for either of the two an equivalent couple be substituted, the equilibrium will not be disturbed." These are exactly the conditions that obtain in the operation of a prony brake. The torque acts as one couple, the brake acts as the other. One of the two forces of the brake couple acts at the extremity of the brake arm and is the force measured; the other acts vertically through the center of the wheel to which the brake is attached. As this latter force passes through the axis about which moments are taken, its moment is zero, and the moment of the brake couple is the moment of the force on the scales which exactly equals the torque.

Aside from these considerations, it appears from Mr. Hughes' own formula that he could not possibly have obtained the results he says he did, namely, 110 pounds on the scales with 100 pounds acting. In the line diagram of his figure, shown herewith, I added the dotted line *ab* myself. Mr. Hughes shows that the force acting at *a* equals

$$\frac{Z}{V+Z}\left(W+W\frac{X}{Y}\right).$$

Now this expression may be reduced to

$$\frac{Z}{V+Z}\times W\left(\frac{Y+X}{Y}\right).$$

Referring to the diagram it is seen that the triangles *abc* and *cde* are similar.

Therefore,

$$\frac{X}{Y}=\frac{V}{Z}.$$

Hence,

$$\frac{X+Y}{Y}=\frac{V+Z}{Z}.$$

Substituting this in the simplified form of Mr. Hughes' formula, we have:

$$\frac{Z}{V+Z}\times W\times\frac{V+Z}{Z}$$

which reduces to W and shows that, in spite of Mr. Hughes' experiment, the force measured on the scales exactly equals the weight on the lever arm.

J. CHASE.

Philadelphia, Penn.

Comments on Divers Topics

I thought I was going to learn something about producer gas from the article headed "Hydrogenless Gas" but I didn't. We have to make a million and a half feet of scrubber-producer gas every 13 hours to hold our job, so we never overlook anything on this subject. A fairly close perusal of everything published on the subject has convinced me that most of the knowledge along this line is mere theory. We are furnishing the gas for heating and part of the power in one of the largest plants of its kind in the United States, and know that the plant, as installed, was unworkable.

As to the effects of hydrogen in an engine, I do not think it will cause any trouble in a properly designed engine; it has not with us, and at times, I have had the producers handled in a way to produce the greatest percentage of hydrogen.

When I read a flowery description of some installation, whether gas, steam, turbine, or what not, I get to wondering what the fellow who has to make it go thinks of it and what his troubles are. It is easy to make things look nice on paper no matter how impractical they may be.

The "Uncle Pegleg's Philosophy" article interested me greatly because I was brought up in a sawmill. The photographer shows one familiar object, the cylinder head, but that roll-top desk and the other belongings of a first-class office I don't recognize, and I don't believe any other real-for-sure sawmill engineer does either. But the engineering work sometimes accomplished in a sawmill would stump the fellows in the engine room where they do have roll-top desks.

I don't differ with W. H. Booth, but sometimes pumps will draw water nicely where the pump is not at the highest point. In one case the man who made the pipe ditch was not expert at maintaining his grade, and as a consequence the pipe line was higher than the pump at one point, but we had no trouble. In some cases I find a foot valve necessary; in others, the pump won't get the

water until the foot valve is taken off. You can't always tell, for it is not always possible to analyze the conditions correctly.

Next week, we are going to try an impeller pump; it might be called this or a screw pump. I have seen this type of pump raise 1150 gallons of water a minute out of a 10-inch well, but consider an air lift with a good compressor the correct thing.

J. O. BENDER.

Anderson, Ind.

Misleading Statements in Advertising Matter

I notice in a recent advertisement, the following:

"Exhaust steam will give up its heat faster to the radiating surfaces than will live steam from a reducing valve. Live steam that has been passed through a reducing valve is in a superheated condition, that is, it is a gas, and gases are poor conductors of heat. That is one reason why you superheat steam for the engine, so that it will not give up its heat so readily to the cylinder walls."

The best authorities agree that the rate of heat transfer depends upon the relative temperatures of the heating agent and the agent to be heated, no matter what they may be. From this it is clear that the first part of the above statement is erroneous.

As to the last part of the statement, "that is one reason why you superheat steam for the engine, so that it will not give up its heat so readily to the cylinder walls," we do not superheat steam so that it will give up its heat less readily to the cylinder walls, but we superheat in order to avoid some of the loss of power due to initial condensation. It would be reversing well-accepted thermal laws to say that with greater temperature range the transfer of heat is less than when the range is low. If we superheat steam sufficiently to enable it to part with some heat without condensing on entering the cylinder, we avoid a considerable loss. The amount of saving will depend on the relation between the cost of superheating, and the losses due to operating without superheat.

The moral is, advertisers should be careful not to make misstatements. If their products are meritorious, they do not need to resort to fabrication to boost the sales. Of advertisers whose products are without merit I have nothing to say. Inaccuracies recoil upon their authors to fill them with dismay.

In the last analysis, advertisers who make inaccurate statements, purposely or otherwise, are bound to lose through the discredit they incur.

WILLIAM WESTERFIELD.

Lincoln, Neb.

Lubricator Improvements

I saw an article in POWER AND THE ENGINEER where someone was having trouble with a lubricator because the oil ran up the side of the glass. I have had the same trouble many a time, especially in cold weather when the engine room was cold. Now, the way to overcome trouble in that case is very simple. Take the plug out of the top of the sight-feed glass, same as though you were going to put in a new glass, solder a fine piece of smooth wire to the inside of the plug and bend the wire so that it will come as near the center as possible, then cut the wire allowing ⅛ inch clearance between end of wire and point of feeder; the oil will always follow the wire.

E. M. WELLS.

Dunkirk, Ind.

Proper Joint for Iron Smokestacks

About twelve years ago I erected two iron smokestacks at a coal mine. Through some mistake of the builders one stack was constructed as in Fig. 1, and the other as in Fig. 2. Being in a hurry to get the stacks up, we erected them as they were. Four years later I visited the plant and to my surprise found the stack shown in Fig. 1 rusted off at a joint two-thirds of the hight from the bottom. I had supposed that this stack had been properly erected. The other stack was apparently as good as ever. The stacks were both new when erected and made by the same firm. They were given a coat of asphaltum paint once a year. The engineer in charge of the plant told me that the stack constructed as in Fig. 2 never seemed to need any paint, while the other one

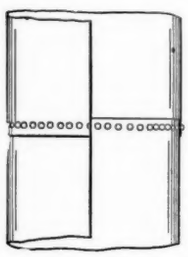


FIG. 1

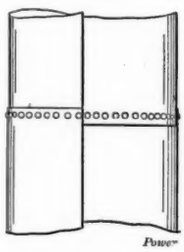


FIG. 2

always began to show rust streaks below the joints shortly after it had been painted. I account for the well preserved state of one stack by the fact that the paint, when applied, would run into and fill up the joints. The joints of the other stack, not being completely closed, allowed any water running down the inside to leak through. This water carried with it acid from the flue gases, which readily attacked the paint.

GEORGE W. SHILLING.

Massillon, O.

A Condenser Question

In reference to the condenser question by Joseph S. Labonne in the December 21, 1909, number, I venture the opinion that should the injection water be cut off, and the throttle closed at practically the same time, and while the tail pipe was not submerged, conditions would be favorable for a smash up due to the tail pipe acting as an air lift and flooding the cylinder with water before the engine could be brought to a dead stop. But I hardly think there is any danger as long as the injection water is on and the condenser has the proper elevation. I operated a plant in which there was a Knowles condenser for some time, but never tried to see what would happen under these conditions, so I hope Mr. Labonne will take my remarks for all they are worth. They are merely an expression of opinion.

J. W. FOWLER.

Richard City, Tenn.

In the issue of December 21, Mr. Labonne asks for opinions on the failure of an injector condenser installation having its discharge pipe unsealed.

There is a degree of vacuum in the condenser itself, caused by the mixture of steam and water, and the pressure therein is below that of the atmosphere. Therefore, with an unsealed tail pipe, air will enter and travel up this pipe in spite of any quantity of water that may be sent through the condenser, and the vacuum will be broken. Not only that, but the column in the tail pipe will consist of a series of layers of air and water coming down, and in the inclined branch, a film of air moving upward along the top of the pipe. The condenser being so close to the 45-degree elbow, allows this air to rush into the condenser cone itself.

The final layout, as shown in his illustration, is not the best for efficiency. As near as may be judged in the adsence of dimensions, the condenser is too low. The water should have a fall of 34 feet from the level of its entrance into the condenser to the level of the tail race. The bend in the pipe is too close to the condenser. To make a job of the installation, it would be well to get an old tank deep enough to seal the pipe for about 3 feet and place it so the tail pipe will be straight, and from the top of the tank, run out an overflow to the tail race, with a slight pitch downward.

The frothy appearance of the discharge from the unsealed pipe is an indication that the photograph was taken when a mass of air, water and uncondensed steam was being discharged.

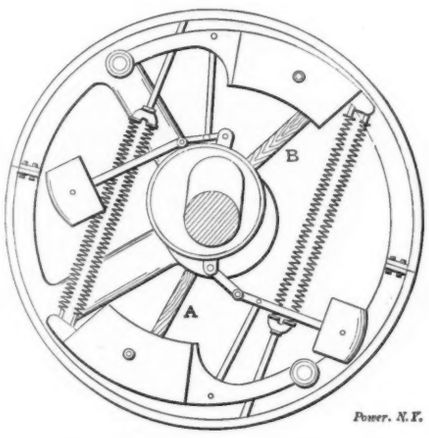
FRANCIS W. BRADY.

New York City.

An Unexplained Accident

I did not intend to mention the matter but as no one else has said anything about it, I guess it is up to me. What I refer to is: "An Unexplained Accident," by W. H. Wakeman in the October 26, 1909, number.

He shows a cut of an engine governor with the weights blocked out to their extreme throw and claims that while it is in that position the longest possible cutoff is obtained, also that when the engine is at rest the eccentric takes a position directly opposite to that shown in his figure, which is herewith reproduced. Accordingly then when the engine is at rest or just starting the eccentric must be in such position as to give the least cutoff and as the engine speeds up the governor arms move outward and give the engine more and more steam. Really,



GOVERNOR GIVING LONGEST POSSIBLE CUTOFF

I think it must be an oddly designed engine, for all engines I have ever run or seen, functioned exactly opposite to the one described by Mr. Wakeman.

FRANK AVIS.

Garfield, Utah.

Criticisms of Diagrams

In the December 21 issue, page 1036, there are two sets of indicator diagrams from a compound Corliss engine. There are some points about these diagrams which I would like explained. In Fig. 1 the writer of the article states that the exhaust valve is open up to the point of cutoff. But the diagrams show an early closing of the exhaust valves and the initial pressure is higher than in the diagram in Fig. 2 from the high-pressure cylinder, which to my mind would be something out of the ordinary, if not impossible, if the exhaust valves on the high-pressure cylinder were open until the point of cutoff.

How is it that the back-pressure line runs parallel with the atmospheric line? Would not the back-pressure line change as soon as the exhaust valve closed? As the second set of diagrams show less compression and earlier release it looks as if someone had shortened the exhaust-valve connections, giving less compression and earlier release. If the exhaust valves allowed steam to blow into the receiver would not the steam line on the low-pressure diagrams be higher than shown in Fig. 1? I may be wrong, but as I'm always interested in steam engineering I will be pleased to have some explanation of the diagrams. I should say that in Fig. 1 from the high-pressure cylinder the pencil arm met some obstruction which made that sharp drop.

MICHAEL H. HARRINGTON.

Fall River, Mass.

Cylinder Lubrication

I am installing an 400-horsepower high-speed single-valve engine making 200 revolutions per minute. I would like the opinion of readers on cylinder lubrication. I have had considerable experience in marine work where very little oil is used, and I intend to start this engine without cylinder lubrication.

H. H. WILBON.

Kila, Mont.

Flake or Powdered Graphite?

The writer has been much interested in the articles appearing from time to time on the question of graphite as a lubricant, and the differences of opinion of practical mechanics regarding the relative merits of the different kinds, flake and amorphous or powdered.

The subject is one of great interest to me. Being engaged in the manufacture of a graphite lubricating device, I have given it close thought and investigation. The amorphous graphite I find will fill up the microscopic depressions which are sure to be present in even the most carefuly finished bearing surfaces. The amorphous, being soft and fine, will fill the hollows and cover the points, forming a graphite veneer that makes a remarkably smooth surface reducing the friction to a marked degree, while the flake, being tough and coarse, has a tendency to accumulate on the metal points, which cause it to ball up and create friction.

PETER THACHER.

Chicago, Ill.

The articles appearing in POWER regarding the use of graphite as a lubricant, have interested me very much. I notice in particular an article by H. Jahnke.

I cannot agree with him, as my experience has been that flake graphite will work out of any ordinary bearing, and when used for cylinder lubrication it will pass entirely through the cylinder, leaving with the exhaust, while powdered graphite will work into the pores of the metal, even up the surface, and leave a smooth, polished bearing. One instance of the superiority of powdered graphite occurred after having the cylinder of our 16x18-inch center-crank engine rebored; a new piston and new rings had been put in and the fit was so tight that I could not keep the engine running without heating for more than five minutes at a time. I sent out for some of the best cylinder oil I could buy and flooded the engine cylinder with it, but got no better results. I then tried flake graphite and cylinder oil mixed together and still I could not get the engine up to speed without heating. A friend advised me to try some powdered graphite. I mixed some finely powdered graphite with cylinder oil and fed the mixture into the cylinder through the lubricator. The result was most gratifying; I had no trouble in getting the engine up to speed, and have had no trouble since.

I am now using this mixture of powdered graphite and oil in all my cylinders and for other lubricating purposes and have reduced my oil expense 50 per cent. It has been my experience that to get the best result from powdered graphite it must not be used too freely. I mix about one teaspoonful in a pint of oil. I have no trouble whatever in feeding this mixture through the lubricator.

JOHN MEYER.

Cleveland, O.

The Twelve-hour Shift

N. T. Oden's article on the twelve-hour shift together with a recent editorial, "The Hoisting Engineer," made me desire to say something about the effect of the twelve-hour shift on the operator in large winding plants.

The hoist man must during a shift answer hundreds of signals nearly all of which require him to plan his movements ahead so that none of the signals conflict. Ofttimes he has to carry several signals in his mind until he has an opportunity to answer them. He can never see the results of the movement of the cage or bucket in the shaft. He is fearful of any loss of life that may occur through some unconscious error on his part. These things keep the nerves of the man behind a hoisting engine at a high tension and nearly always he leaves work completely worn out.

Recently the legislature of this territory passed an eight-hour law for the benefit of the hoist men, but in a few months it was declared unconstitutional. In some instances employers discharged their engineers because they refused to work more than eight hours. The law was, however, not without some good results, as many employers seeing that the standard of work was improved by three shifts instead of two, continued the practice.

It is to be hoped that in the near future steps will be taken to aid engi-

neers of all kinds in securing a shorter day. If shorter hours could be secured the work that an employer would receive from his engineers would be of better grade as there would be more time for study and the engineer would extend his studies to cover a greater number of subjects. The shorter day would ultimately create a better class of engineers.

EARL E. WEBSTER.

Mesa City, Wyo.

Steam Cylinder Used as Pump

Mr. Peterson has asked me to explain how a steam-engine cylinder can act as a pump, using exhaust pipe as a suction pipe. A pump piston in its movement forces the water which is in front of it away, at the same time creating a vacuum on the opposite side and atmospheric pressure forces the water into the pump cylinder through the suction pipe.

Suppose water to be in the exhaust pipe as explained in my previous letter, and that the engine is of the vertical type. First, on the piston rising, the lower steam valve is opened, the lower exhaust valve closed and continues closed until the piston reaches near the top of the cylinder, when the bottom exhaust valve opens, and the water contained in the exhaust pipe rushes into the cylinder. The piston, descending, meets the water and as soon as the exhaust valve closes, smash goes the cylinder in many cases.

Further information on this subject is found on page 1116 of the December 28 issue.

WILLIAM MELLER.

Brooklyn, N. Y.

Kerosene in Boilers

I have read with much interest articles in POWER in regard to kerosene as a scale remover and preventive, but my experience has taught me that it is not much help in removing scale. I think, however, if used at the proper time, it will help to keep the scale down a little. I always wash out a boiler about once a month. I put in a bucket of kerosene before I put in any water. When the water rises the kerosene will float on top and spread all over the shell and tubes. To feed kerosene in when you have steam up, does very little good.

I had charge of a plant in which there were two 90-horsepower, return-tubular boilers. We were using city water with good results, but as about 30 gallons a minute were required for the various parts of the plant, the water cost became so great that the firm decided to sink a well. After this my trouble with scale began. I removed about a half bushel of scales from the bottom of each boiler every month or six weeks. I had the water analyzed and found it to be very bad. We began using a compound and that did fairly well. About the time that barrel was used up, I made a change in my position and was away for a year, then returned to my old place again. In my absence no compound had been used and the boilers had been cleaned but once. The fireman was burning all the coal he could get into the furnace and found it hard to keep steam at that.

My first thought was POWER, all my back numbers of which I had stowed away. I came across a tube-cleaner advertisement and wrote for one for a thirty days' trial.

The result of the cleaning of one boiler was a saving of between four and five thousand pounds of coal in seven days and nights. The total cost of the outfit was $90, which I paid off from the saving in the coal pile in less than four months.

I would advise my brother engineers who are troubled with scale, and are not afraid of a little work about every six weeks, to get a mechanical tube cleaner. It is the best remedy for scale I have come across during the 15 years of my experience.

W. B. ARCHER.

Alexandria, Va.

For some time past, I have noticed in the pages of POWER a discussion as to whether or not kerosene oil is effective in removing scale from a boiler. Early last spring we installed an additional boiler, which was second hand and had been used some three or four years at a place where the water supply came from a deep well, and was very hard. When we received the boiler it had a thick scale all over the bottom of the shell and tubes. At the heads the deposit was so heavy that the spaces between the tubes was entirely closed for several inches, and where the braces were riveted to the heads, the deposit hung in chunks as large as a man's head, and was so hard that we could not make much impression on it with a cold chisel. We decided to try kerosene oil, and sent a man in with a bucket and dipper and had him thoroughly saturate all the deposit on the shell, head and tubes; this required about 15 gallons. We allowed the boiler to stand a few days, then filled it with water and fired up, brought the pressure up to about 80 pounds and then pulled the fire. After cooling we examined the inside and found most of the scale had fallen down; what was not down could very easily be jarred loose with the blow of a hammer.

We continued to use kerosene about once a week for a month or so, putting in about a half gallon after washing out, and now there is very little scale in the boiler. We did not use the sudden-cooling-off process either; the water was not let out of boiler until we were ready to take out the manhole plate.

This is my first experience with kerosene as a scale remover; I do not say it will remove scale from all boilers, but it seemed to be the proper remedy in this case.

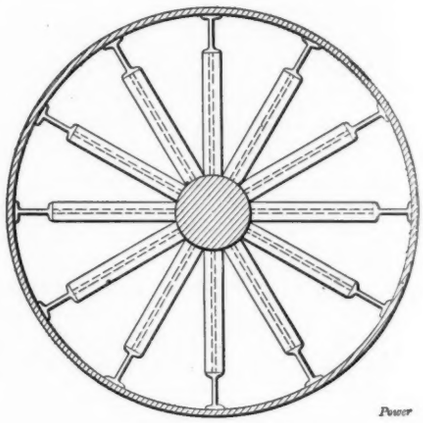
W. M. PRICHARD.

Datura, Texas.

Designing a Vacuum Tank

Replying to the query of George P. Pearce in a recent issue as to a formula or method for designing a vacuum tank 8 feet or more in diameter and 16 feet long, I know of no formula for the purpose.

The Board of Trade and other formulas for cylinders or flues to resist external pressure are intended for marine-boiler flues, which, I do not think ever exceed 48 inches in diameter and I would not consider it safe to apply them to cylinders of large diameter. I would not design a tank of such a diameter as 8 feet to resist an external pressure of, say, 14 pounds



BRACING OF TANK

per square inch, if I could help it. If I had to design such a tank I would ask the leading tank builders if they had any experience in building one of 8-feet diameter, and if they had not I would build it with steel I-beams for longitudinal ribs supported at the ends and two or three places in the middle by spiders made of I-beams, abutting against a central block, and cover the skeleton thus made with sheet steel. This would be a very expensive tank, but it would be strong. The spiders, of course, would be braced to resist the end pressure.

WILLIAM KENT.

Chicago, Ill.

In screwing pipe fittings together spread a thick mixture of graphite and oil on the threads. This will help make the joints steam or water tight. White lead is used when the pipe is not to be taken apart again. It hardens, while the graphite does not, and makes it almost impossible to unscrew the pipe fittings when they have been connected for a long time.—*Gas Review.*

The Tax Exacted from Excess Air

BY HENRY J. WESTOVER

Only a few, of the many interested in the reducing of coal bills, realize how much money is daily lost in the heating of useless volumes of air in the boiler furnace during the process of combustion. It is a fact, proved by a number of tests, that an experienced fireman will use 170 tons or more air per day than another fireman, both burning the same amount of coal.

If the matter were brought to the fireman's attention many would tell you, that judging from their experience, the amount of the air entering the furnace makes practically little or no difference in the amount of coal burned each day. Air is free; therefore, what difference does it make, as long as they keep the fire doors closed.

The fact of the matter is, this subject has received but scant attention from the manager or engineer, as compared with its importance. Of course, there are a number of exceptions; many eminent engineers are studying the matter very closely and their efforts have been amply justified by the results obtained. There are others, however, who have only gone into the matter halfheartedly and have been more interested in finding holes to crawl out of rather than to push the investigation to a finish.

Some engineers will tell you that in burning coal it gives up all its heat, and ask what more can be expected? This is very true, and if the coal is burned, it has given up all its heat, but how much has been captured and stored up in the boiler? If all the heat given out by the burning of the coal has been stored up in the boiler, nothing more can be expected and the case would be closed; but it is not.

A certain amount of air is necessary in the burning of coal. A fireman, hand firing, will handle about eight tons of coal per day. If the coal runs 80 per cent. combustible the best results are obtained with the use of 115 tons of air for eight tons of coal; but as before stated from repeated tests, it is a common thing for a fireman to use 285 tons of air for this amount of coal, a difference of 170 tons. If this quantity of air had been delivered to the chimney at the same temperature as it entered the fire, there would have been no loss, but this excess amount of air is delivered to the chimney at a temperature of about 525 degrees, more frequently above this temperature than below it. It is self-evident no one can heat 170 tons of air, raising its temperature 450 degrees Fahrenheit, without costing money, and this cost is the amount of money the owner is out each day, viz., the difference of the amount of air used and the amount actually necessary. The coal has given up all its heat, but not to the boiler; a large part has been waylaid and this takes place every time excess air is permitted to pass through the furnace.

Boiler Tests

Several years ago the writer conducted several hundred boiler tests where both coal and water were carefully weighed, gas analysis made, the air measured by anemometer, to check the gas analysis, and temperatures taken.

Three boilers, part of a large battery, were specially equipped for testing purposes, also to obtain the best results. About 80 experienced firemen were employed on this plant and each man took several turns at firing at these tests.

The conditions for each man were made as nearly the same as possible. The boilers were clean, all the flue doors and cleaning doors were fitted as tight as a good machinist, by chipping and filing, could make them. The setting was thoroughly overhauled and put and kept in good condition.

Before starting the tests each week the boilers were washed out. The doors and damper were then closed and oily waste burned in the furnace, and if any smoke was discovered coming out at any point in the setting the mason repaired it at once. This was done to cut down the infiltration of air to a minimum. The burning of oily waste was the test to detect air leaks.

In making these tests the men used the same grade of fuel, the same grates, and each man burned about one ton of coal per hour, employing the same methods in handling it. The rule was light charges and often, placed alternately on each side of the furnace in rotation, returning to the first boiler for the other side. This was done for coking purposes.

Results

The maximum variation at first in the results obtained amounted to 25 per cent. The men were told of the amount of air they were using as the tests proceeded, also the results by evaporation.

The men soon caught on to the fact that those using the most air made the poorest showing. It goes without saying that a few tests of this kind set the firemen to thinking. Those who had shown the best results from the start had been very careful about the air supply; the others, who could not be convinced by being told, sat up and took notice. Within a few months the average difference in results had been reduced to 13 per cent. and the maximum difference in the air supply to about 8 per cent.

The most satisfactory evidence, however, was the greatly reduced coal bills.

These tests had demonstrated this fact, that the difference in the amount of steam raised per pound of coal was more a matter of the fireman's manipulation of the air supply than any other feature under his control, that is to say, keeping the bed of fuel at the requisite depth, free from ash, holes, closing the damper when firing and cleaning the fires, and other features having to do with the correct air supply. Before these tests were started anyone passing through the boiler rooms would not have detected anything out of the common practice, but would very likely have been surprised at the orderly and methodical way things were conducted.

The coal bill on such a plant was of too much importance to permit of any visible waste. There were too many eyes watching, too many eager to report a waste if discovered; yet for all that, this waste in excess of air had eluded them all, because it could not be seen.

The actual difference in results at first averaged more than one ton of coal per man per day, making a total of 80 tons per day.

The Remedy

It would be useless to call attention to the possibility of such a waste taking place if it could not be made visible and corrected. This is possible and within the reach of all.

There is no mystery attached to it; it is simply getting wise to the amount of air passing through the furnace and preventing an excess.

There are several ways of determining this: You can use an anemometer, or a pyrometer or make an analysis of one of the products of combustion, for example, the carbon dioxide.

This last method may appear very difficult and out of the reach of the man in the boiler room, but science and invention have placed it within the reach of all, and it is as easy and as accessible as the reading of the steam gage. The fireman has only to look at the front of the boiler to see at once if he is using 10 tons or 200 tons too much air each day. This is accomplished by a known law in chemistry, whereby one value having been ascertained the other values bearing a known relation to this can be figured. For example, when the percentage of the volume of carbon-dioxide gas has been determined in the products of combustion the exact amount of air passing through the furnace per pound of coal can be figured. This method is not only the most exact and reliable but it is the method most easily carried out

automatically by machinery so that no technical skill is required. If a lot of technical work had to be done, many would consider the remedy worse than the disease, but this is not the case. Apparatus that any fireman can understand can be obtained in the open market.

Of course, if the fireman could see the air, he could judge, approximately, the amount he was using, but not being able to see and measure air he is certainly at a great disadvantage. If the owner desires to see his coal bill reduced, he certainly should not be adverse to providing the man able to accomplish this the means of so doing. If the management is not concerned enough to do this, how can it be expected that the fellow not financially concerned will grope in the dark, blindly trying to accomplish something away out of his reach? For at the best his efforts would be only guesswork.

Coal in the Engine Cylinder

BY F. W. BRADY and C. J. MASON

The coal flowed into the engine cylinder, and———don't throw that brick! gentle reader. Put it down and be calm, for this story is strictly true, though stranger than any power-station fiction ever written. You need to hear the story of this engine wreck. It is the unexpected that always happens, and some day you might have a smash-up, and maybe it will be caused by sawdust, fish or bats in the engine cylinder.

But, as we were saying in the beginning, the coal flowed into the low-pressure cylinder and in less than a minute the low-pressure side of a beautiful 2400-horsepower unit was a wreck. It was not an internal-combustion engine, nor was the presence of coal in the cylinder caused by improper firing in the boiler room. On the contrary it was a brand new, cross-compound engine of 2400 horsepower capacity driving a single direct-connected street-railway generator at 100 revolutions per minute. Also, the boiler room generating 150 pounds steam was brand new, and its efficiency would be difficult to excel, and this too by using a fuel of lower grade in some respects than that which went into the cylinder.

The plant is located on the banks of the Lackawanna river in the anthracite mining region of Pennsylvania, and thereby owing to this fact hangs the following tale.

For a year or more the Scranton Street Railway Company had been improving its system in a most excellent and substantial manner. Single tracks were made double; 80-pound rails were laid with steel ties on a concrete bed; curves, turnouts and crossings of the best construction were put down. Additional cars and a more frequent service called for power-house additions, and these have been met by projecting a new uptodate station entirely separate from the old station. The first section of this station, which will be eventually 500 feet long, was completed about one month ago. It is a roomy building built of brick, concrete and steel. All of its features conform to good practice, both in an engineering and in a business sense. The first unit began its operation beautifully, and the entire station was the pride not only of the engineers who designed it, but also of the erecting engineers, and the corps of very efficient operating engineers and firemen. Three weeks of service and a ten-hour special test showed that the station would make good, and hence everybody was happy.

A heavy concrete wall borders the river, and through this wall are the openings for the inflow of water to the suction basin and for the overflow discharge from the barometric condenser. The condenser stands outside the building and is of the usual four-pipe construction; one pipe leads to the low-pressure cylinder; one to the centrifugal pump in the basement that delivers the condensing water; one to the horizontal flywheel plunger pump on the engine-room floor which removes the vapor and air from the top of the condenser head; and the fourth pipe is the atmospheric exhaust.

Now then, after having this general idea of the layout, let us look to the coal-in-the-cylinder problem. The engine was shut down one evening after a successful run for the day. Next morning a start was made in the usual way. The vacuum pump made 20 inches. The engine was brought up nearly to speed and the generator to 500 volts, the engine exhausting into the atmosphere. Ordinarily the water comes over from the centrifugal circulating pump in a minute or so, but this time something was wrong, the vacuum pump stopped suddenly, and the vacuum was lost at once. The pump could not be budged with 150 pounds of steam assisted by the attendants pulling on the flywheel. At a signal the throttle was closed and the engine slowed down. Then the smash-up happened. The top of the guide barrel was split off, the piston rod got a kink next to the crosshead, the connecting rod was bent, the key in the crank disk was partly sheared off and the valve gear knocked awry, with some of the castings broken. The whole sequence of events took place almost too quick to think.

And the cause? Well, it was found that the whole system, beginning with the tail pipe, was plugged with coal—culm they call it for short, the word expressing the entire make-up of the fuel in size, quality and condition. A freshet in the river had brought the supply from the many culm piles that encroach upon its banks. Anthracite coal moves readily in a current of water. The centrifugal circulating pump received a few wagon loads of the floating fuel and promptly filled the tail pipe of the condenser solid with it. Then the stuff came over to the vacuum pump and filled that. When the engine slowed down and gave some vacuum in the low-pressure cylinder, this too got a supply of culm, which came with the water by way of the air exhaust from the vacuum pump, as this exhaust enters the engine atmospheric exhaust pipe. Finally, the momentum of the big flywheel and the generator armature pushed the piston against the water and culm in the cylinder and the weakest section of the construction had to give way.

The clean up was a case of coal mining, but the job was not done by union miners. The cylinder came out unscathed, and the crank pin and shaft were uninjured. Also, the crank disk was unhurt, but it had to be drilled and split off on account of the partly sheared key. The guide barrel formed one solid casting with the bed and pillow block and this large casting must be replaced. The split of the guide barrel was evidently caused while the crank pin was moving upward from its lowest position. This position gave the greatest upward pressure against the upper portion of the barrel, and the housing being of thin section could not resist the force. The joint at the crosshead formed a knuckle. The stuffing box held the piston rod horizontal, while the crosshead went up into the air and gave a sharp bend to the end of the rod. At the same time the lower front edge of the crosshead formed a fulcrum for the connecting rod near the crosshead pin, causing the rod end to be bent downward.

The old plant had been operated for years under similar conditions of condenser-water supply and no trouble whatever had been experienced. It was a circumstance unthought of from past experience, and old hands at the business hardly believed the facts even after seeing the coal pile mined from the piping system.

Disastrous Economizer Explosion

The explosion of a Greene economizer in the Edison Electric Light Plant, Paterson, N. J., at 4:42 o'clock, Friday afternoon, January 21, mortally injured one man, and seriously injured eight others, besides blowing the economizer into hundreds of pieces, demolishing the roof of the boiler house immediately over the exploded economizer, blowing down a part of the side wall and a portion of the end wall. The illustrations, Figs. 1 and 2, show the condition in which the boiler house was left after the explosion.

The boiler room contains ten 500-horsepower, water-tube boilers, carrying 160 pounds steam pressure and arranged in batteries of two each. Six of these boilers are set on one side of the firing alley, while the remaining four are set on the opposite side, facing the six boilers. The economizer that exploded was set above the first two of a set of four boilers, the economizer of the other two boilers being arranged in the same manner, but was practically uninjured. This arrangement allowed the gases coming from the boiler tubes to pass through a flue under the economizer to one end and then between the economizer tubes to the uptake, placed between the two economizers, and passing up over the coal bin to the stack, which is located on the opposite side of the boiler room.

Above the boilers, a 12-inch header was suspended, at a hight of about 7 feet above the center drum of the Sterling boilers. The boilers were connected to this header by an 8-inch pipe fitted with a nonreturn valve and a regular type of stop valve; one such arrangement is shown at the bottom of Fig. 2. Above the stop valve a cast-iron offset pipe was connected to the header by flange joints. This header connected with the header over the six boilers on the other side of the boiler room by the pipe shown at the end of the coal bin, Fig. 2. At this point the pipe was fitted with a swing joint; that is, fitted with a tee, a short drop nipple and another tee, to which the header running lengthwise of the boilers was fitted. At the end of the second battery of four boilers this header turned up and passed over the top of the coal bin and again connected with the header over the six boilers.

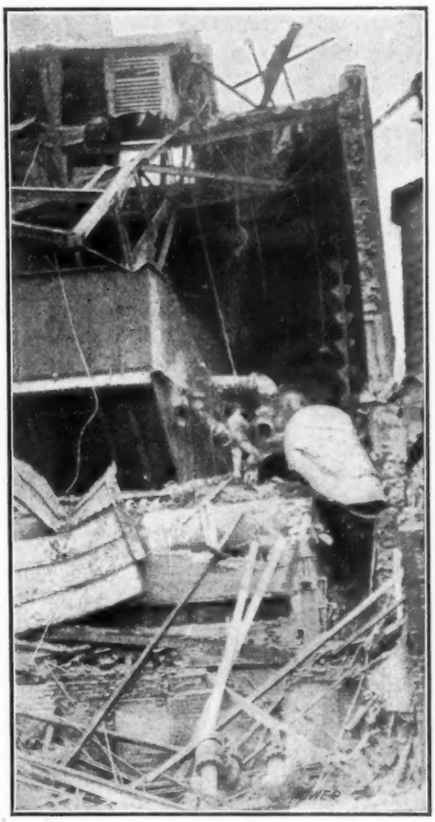


FIG. 1. TOP OF BOILER AND ECONOMIZER PARTS

The force of the explosion entirely destroyed the economizer, only one whole header being found, the others being broken into small pieces. The upper headers were blown into smaller fragments still, indicating that the upper portion of the economizer gave way first. The tubes were also blown into small pieces, there being scarcely a whole tube in the accumulation of débris scattered about the premises.

On one of the four boilers the flanged nipples of the baffle piece were broken off almost square, while others were broken higher up. In one instance the elbow of the 12-inch pipe was split from end to end as clean as if cut with a chisel, not only through the body of the elbow, but through the pipe flange as well. Only one of the cast-iron offset pieces was left intact; in fact, the four boilers were practically stripped of their overhead pipe fittings.

The cause of the accident is not known, nor is it likely to be, as the economizer was so blown to pieces that defects, if there were any, could not be distinguished. There are two theories as to just what took place. One, held by Chief Engineer G. U. Merrill, who has been with the company twenty-one years, is that some-

FIG. 1. SHOWING WRECKED CONDITION OF THE BOILER HOUSE

one made a mistake or neglected to open the feed-water outlet from the economizer to the boilers, and the firemen, not getting sufficient water, supplied the boilers by means of the bypass. In the meantime the water contained in the economizer tubes was being heated and when the pressure in the tubes became high enough the headers and tubes were blown to pieces, the relief valve failing to operate. The economizer had been cut out of service during the day, in order that a blown-out gasket might be replaced in one of the headers. The explosion occurred about two hours after the economizer had been, or was supposed to have been, cut in service again. Engineer Merrill has no proof that this is the case, and is not entirely satisfied that this supposition is correct. It is, however, the more tenable theory of the two, when the condition of the wreck is taken into consideration, as the evidence all goes to show that the explosion was an internal one, and upward, as most of the wreckage was blown up in the air almost directly over the site of the economizer, much of it coming down practically where it started from. The force of the explosion wrenched the steam-pipe fittings from the 12-inch header, which allowed the steam to strike the back wall of the boiler room, such as was left, with a force of 160 pounds behind it, which would account for the wall being blown outward.

The second theory is advanced by Machinist Dixon, who had cut the economizer out of service in order to repair the blown packing in the economizer header. He states that the economizer had not been repaired at the time of the explosion, and that there was no water in the tubes, or hot gases passing them, the gases being bypassed. His explanation is that gases accumulated in the economizer and uptake from the boiler in such quantities as to become ignited by the flame from the furnace, which caused the explosion and wrecked the economizer.

It does not seem possible, if such were the case, that a gas explosion would so completely wreck the economizer, setting and building. It would seem more probable that someone turned water into the economizer and neglected to open the valve between the economizer and the boiler, the pressure generated in the economizer finally causing the explosion. The economizer was installed about three years ago. The thickness of the tubes varied from 5/16 to 9/16 inch in thickness, and the headers from ½ to ¾ inch thick, which would be of sufficient strength for the purpose required.

As a result of the explosion the entire electric-light and street-car service was put out of commission for a time. No sooner had the men in the plant got their bearings as to just what had happened, and removed the injured, than the work of getting the boilers fit to operate under steam pressure again was undertaken. In less than two hours after the explosion the street cars were in operation, but under a reduced schedule, and in less than five hours the incandescent circuits were in working order, four boilers being found fit to use. It will be some days, however, before the entire plant will be in operation again. The representative of POWER, who visited the plant as soon as the accident became known, is indebted to Superintendent William H. Brock and Chief Engineer G. U. Merrill for courtesies extended in imparting information regarding the explosion.

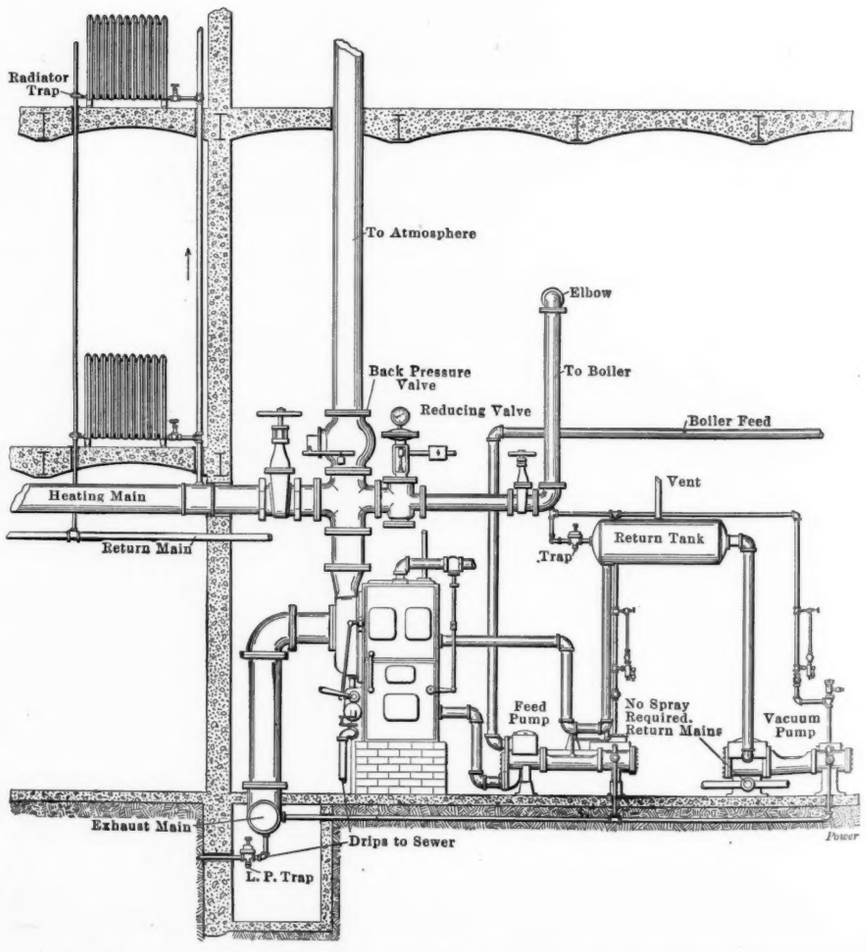
Dunham Vacuum System

In a recent article dealing with piping open feed-water heaters, several exhaust steam-heating systems were illustrated. One, the Dunham vacuum system, was not included, and as it has features distinctively its own, a description will be of interest.

Referring to the accompanying illustration, it will be seen that the system is used with the steam-stack type of heater, the exhaust steam coming from the engine, and after passing through the open feed-water heater, passes either to the atmosphere, through the vertical pipes, or is permitted to pass to the heating main, by closing the back-pressure valve in the exhaust pipe and opening the gate valve in the heating main.

The steam passes to the radiator through the small pipes in the direction shown by the arrow, and returns to the return main and tank, from which it is pumped back to the heater and on to the boiler by means of the boiler-feed pump.

The Dunham radiator trap plays an important part in the successful operation of this system. Instead of valves this trap is used, the diaphragm in it opening the discharge. When a diaphragm is cooled by water or air, the internal pressure is reduced and the surrounding pressure causes it to collapse, which opens the valve and allows the trap to discharge until the disk is again surrounded by steam or hot water of high temperature, when a reverse action takes place and the valve is closed, thus making the system practically automatic.



STEAM-STACK HEATER APPLIED TO A DUNHAM VACUUM HEATING SYSTEM

Conservation Water Power Local Issue

BY BENJAMIN BAKER

"The only basis on which it would be advisable to take the water power would be to receive the water for nothing."

For its bearing on the current "conservation" agitation, this conclusion from an engineering report by F. W. Dean, mill engineer and architect, of Boston, is of considerable importance. Mr. Dean does not mention "conservation," nor dilate on general principles, yet this report to one of his clients has much more than an engineering interest. The bare basis of his decision was this: Water power was offered to his client at $10 per gross horsepower; coal, at the same point, costs $2.95 per ton—coal was cheap. The water power was not sufficient through the whole year, but required an auxiliary steam-power plant. With coal at the low figure named, it was cheaper, under the particular conditions, to develop all the power needed from a steam plant.

Engineers may well profit by a summary of the facts of this case, and the figures which led Mr. Dean to his conclusion. Fourteen hundred horsepower, 24 hours per day, was required. Records of flow covering a series of years showed that the available water power at 80 per cent. efficiency on water wheels varied from 245 horsepower in the driest month of the year to full 1400 horsepower during the four wettest months, an average of 970 horsepower per month. It was therefore necessary to estimate for an auxiliary steam power, which would be required to furnish from about 100 horsepower in some months to 1200 horsepower or more in the months when the water flow was scantiest; and plainly the steam plant must be capable of developing the full 1400 horsepower maximum when necessary. The make-up steam plant would be required to furnish an average of 646 horsepower during eight months of the year.

The estimates were made on the principle that if the water power was developed, the cost of its operation must be added to the cost of operation of the part of the steam plant required to maintain a steady power of 1400 horsepower. The estimated cost of the steam power was based on an economical compound-condensing engine.

Fixed charges were estimated as follows:

	Hydro-electric Plant. Per Cent.	Steam Plant. Per Cent.
Interest	5	5
Average depreciation	2	4
Average repairs	2	2
Insurance	½	½
Taxes	½	½
Total	10	12
	$6,600	$13,000

Total for water and for steam make-up, $19,600.

For the steam plant, engine house, engine, electric generator, switchboard, etc., the cost was estimated at $72,700; the boiler plant was set at $35,800, a total for the steam-power plant of $108,500.

For the 1400-horsepower water-power plant, including four 300-horsepower wheels, four generators, switchboard, etc., and cost of installing, the estimated cost was $65,600.

The comparative costs of the two systems, namely, the hydroelectric plant with make-up steam plant on one side, and the steam plant suppyling all the power, are summarized in the following table:

SUMMARY OF ANNUAL COSTS.

	Hydro-electric Plant with Steam Plant.	Single Steam Plant.
Fixed charges	$19,600	$13,000
Attendance	4,880	3,780
Water	9,710	
Coal	8,455	21,948
Oil, etc.	467	280
	$43,112	$39,008
Difference in favor of steam power		$4,104

From this it appears that the water power, which means in this case the combined water power and make-up steam power, would cost $4104 more per year to operate than the single steam plant.

"It often happens," is Mr. Dean's significant conclusion, "that it is not economical to develop water power. In this case the low cost of coal is unfavorable to the development. If it were a question of——(naming a prominent New England textile center) where coal costs $5 per ton, it would be profitable to develop the water power, and the saving would be about $11,000 per year for 24-hour power."

Mysterious Boiler Explosions

BY S. KIRLIN

One often reads of "mysterious" boiler explosions, but considering the number of boilers which are in charge of men totally unfit to handle them, the "mystery" is that there are not far more than there are. The only reason seems to be that there is a sort of providence which protects people who undertake to handle things of which they are entirely ignorant.

While making a trip through one of the Southern States, I had to lie over for some time at a small station, and to pass the time, I walked over to a cotton gin which was near the depot. The engine was an old-time slide-valve affair, and it would have required no great stretch of imagination to believe that it was the same one which Noah used when he made his famous trial trip with the ark.

Every time it completed a stroke in one direction it showed a decided aversion to making the return trip, and would probably not have done so only for the assistance of a heavy flop of the drive belt which seemed to come at just the right time to help it over the center. The steam was coming out of the exhaust pipe with a loud roar, but by listening carefully one could notice a slight interruption at times which seemed to indicate that the valve occasionally got in the way of the otherwise uninterrupted passage from the boiler.

I could see no sign of water in the glass, but as the water column was almost covered with lint and dust from the cotton it would have been impossible to have seen it without a close view. There seemed to be fire enough under the boiler to furnish steam to several more engines if they had been in proper condition, but the pressure was steadily falling. While I was standing in the door the ginner came into the boiler room and yelled to the engineer to, "get that steam up, and be quick about it."

The "culled gem'man" who acted as engineer, came ambling in from where he had been leaning against a post outside, and proceeded to shovel about half a ton of coal into the already white-hot furnace. As the ginner turned to leave the boiler room he glanced up at the water glass, hesitated a moment, then walked over and opened the blowoff to the water column. All that came from it was good dry steam, and turning to the engineer, asked him where the water was. The "engineer" replied: "Ah don't know, boss, it war in theah 'while ago; it sholy can't be fah down," and he turned and started for the injector.

It suddenly occurred to me that my train left in about an hour, and as it was all of two blocks to the depot, I started at once for it. When I had gotten what I thought was a safe distance away I took time to look back, and as the building and surrounding landscape still occupied the same positions, I concluded that the "engineer" was probably right, and that the water could not have been very "fah down."

POWER AND THE ENGINEER
DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROBERT MCKEAN, Sec'y.
505 Pearl Street, New York.
355 Dearborn Street, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $4 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 16 Shillings.

Entered as second class matter, April 2, 1908, at the post office at New York, N. Y., under the Act of Congress of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

During 1909 *we printed and circulated* 1,875,000 *copies of* POWER.
Our circulation for January, 1910, *was* 130,000.
February 1..... 35,000
None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

The Steam Boiler of the Future

To forecast the future of literature or of art is not an easy task, but in mechanical matters, the problem is rather a simple one if mechanical methods are used. The law which governs a sequence of events in engineering practice can be determined by plotting a certain number of points on cross-section paper and drawing the curve; it is then an easy matter to project the curve into space for a moderate distance and thus show the future probabilities. Let us see if we can establish a few points in the history of steam boilers and thus locate its curve.

The first boiler used for furnishing steam to the engine was but a modification of the kettle of the kitchen, a nearly spherical vessel of cast iron with a closed top, wholly or partially inclosed in brickwork. The substitution of steam for atmospheric pressure proved the unsuitable nature of cast iron and wrought iron took its place. Necessarily, the boiler shape changed from spherical to cylindrical, hemispherical cast-iron ends still being retained. Those in turn disappeared and flat wrought-iron ends stayed with long rods made their appearance. The cylindrical boiler thus evolved was one of large capacity both for water and steam, but one of limited heating surface and slow rate of evaporation.

To increase the area of heating surface, two methods were tried, radically different and leading to different types: (a) The introduction of flues or tubes for the passage of the hot gases through the water space; (b) the use of water legs and supplementary water cylinders beneath the boiler and contiguous to the fire. From the former came the multitubular fire-tube boiler; from the latter, the sectional or water-tube type.

The introduction of internal fire boxes had this same purpose, to increase the area of contact between the hot gases and the metal.

Passing over the intermediate stages, such as flue boilers, French or elephant boilers and the like, we find in 1860 the horizontal return-tubular type in favor and in most general use. Today it has few superiors for low-pressure service and for heating. Its characteristics are low first cost, simplicity, ease of cleaning and low maintenance charges. In marine service, calling for a compact, self-contained unit, with no fire in contact with the main shell, the Scotch boiler became the favorite.

Pressures began to increase rapidly about this time, partly owing to the more general use of compound engines. Return-tubular boilers began to fail under the strain, lap joints were discarded in favor of butt joints with straps, and steel was substituted for iron. Even the sturdy Scotch boiler groaned under the new requirements and the thickness of its shell reached impracticable limits. Slowly but surely the water-tube boiler pushed its way into favor despite its disadvantages, i.e., its high first cost, its numerous joints, the difficulty of cleaning and the big repair bills.

It was the only boiler that would stand the pressure. Its characteristics were initial strength, small steam and water capacity, large heating surface and quick steaming—in all respects the antipodes of its ancestor, the cylindrical boiler.

The materials used in the sectional boiler have changed as have those in other boilers. The use of cast-iron headers was soon abandoned, as they made but a weak link in the chain. Steel castings were scarcely safer, but the improvements in drawing and drop-forging steel made possible the use of a metal in the headers in every way as strong and ductile as that in the tubes.

The introduction of curved tubes, to account for the expansion due to the high temperatures and to facilitate junction with steam and mud drums, has marked another change in boiler types. The difficulty of cleaning such tubes is offset by the absence of handhole plates and leaky joints.

The steam launch and the automobile are responsible for the latest development in evaporative apparatus, the flash boiler. No large water reserve, no water line, small bulk and weight, relatively large heating surface, forced circulation and forced draft, put this boiler beside the automobile engine as an example of concentration and intensity—and steam is served to order while you wait.

The less said about cleaning such a boiler, the better. But why should we clean boilers at all?

In olden times, people ate what they pleased or what they could get and drank indifferently water, milk, beer, without a thought of subsequent internal difficulties and disorders. The family physician was called in and prescribed liberal doses of calomel, epsom salts and castor oil, to neutralize the evil results of such an indiscriminate diet. Today people eat and drink with more care and take less

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medicine. Why not take a little pains to give our boilers pure water instead of filling them up with sand and scale and then administering emetics and cathartics on the device of the first quack who happens along? Why not run a clean fire and keep the soot off the tubes instead of cleaning them twice a day?

Having obtained a few points on our historical curves, let us imitate the political economist and project them a short distance into the future.

1—Capacity. Relatively speaking, the water and steam capacity of boilers has steadily diminished; reserve capacity seems less important than quick steaming.

2—Heating surface. As the capacity has diminished, so has the heating surface increased relatively and what is more to the purpose its efficiency is greater; that is, more steam is generated per square foot of surface. The number of square feet of heating surface per horsepower has diminished from twelve or fifteen to ten or even less.

3—Pressure. From the old wagon boiler with its manhole cover resting loosely in place, it is a far cry to the modern locomotive, marine or stationary water-tube boiler carrying a pressure of two or three hundred pounds per square inch, and farther yet to the boiler of the steam car giving steam at 600 pounds pressure and 300 degrees Fahrenheit.

4—Circulation. The circulation of water and of hot gases was formerly left much to itself, being a mere incident of steam production. Today the circulation of water is positive and furthermore the gases of combustion are forced around or through the tubes and flues by high chimneys or by blowers.

Recent experiments have shown that a rapid passage of the hot gases over the heating surfaces improves the efficiency of heat transmission. This principle once understood will lead to smaller grates, hotter fires, stronger draft and series instead of parallel transmission of the gases.

The boiler of the future may then reasonably be expected to be compact and concentrated, with a heating surface well differentiated; to have a forced and automatically regulated draft; to be supplied with a forced circulation of pure water and with clean, hot gases depositing no soot on the tubes; and finally it will deliver steam of as high a pressure and temperature as can be successfully applied to the engines then in use.

It will be more economical and efficient, for the cost of a heat unit in steam will be less and the losses due to radiation and leakage will be diminished.

It will be safe, powerful and above all, it will be intense. The fuel side of the problem has yet to be considered, but that is another story.

Avoid Waste

The present movement for the conservation of natural resources does not necessarily mean, as some would seem to interpret, a restriction on the right to use the great riches of nature contained in the forests, the waterfalls and the coal beds of the country. On the contrary, it is recognized that this generation should be permitted to use what it needs and all it needs, of the natural resources available, but it is also recognized that it is our duty to so orderly develop and judicially control the utilization of these resources that future generations will not be deprived of what they need, through the exploitation of the properties for the present benefit of the few at the expense of the many.

But even after Government supervision has done all that it can to produce in the most economical manner a ton of coal, we will say, using scientific methods by which the minimum of waste occurs, unfortunately there still remains a necessary condition in our industrial system, beyond the sphere of any controlling influence, which always will admit of waste of resources that in the aggregate must amount to a large percentage of the useful work theoretically available from the fuel. A man may buy a shipment of coal, and when it is delivered and paid for he may do with it as he sees fit. He may burn it in an installation where it takes eight pounds of coal to deliver a horsepower. There may be a family across the street freezing to death, to which the heat that he wastes by his inefficient operations would be a God-send, and he is dissipating the natural resources of the country just as surely as the miner who leaves half the coal unmined in the pit.

On the other hand, this same purchaser may use his coal in a gas producer where it will return to him a horsepower for every pound, and he will be saving for useful work elsewhere, just so much of the store of energy which has been put here for the good of all. In a certain district there is an enormous hot house, with over one million square feet of glass surface, under which acres of flower beds are cultivated to supply the city markets. To heat this large interior surface requires from fifteen to twenty thousand tons of coal per year. The expense is a legitimate one, however, the business shows a profit and the owner is satisfied. But not far away in the same district is a large traction power house running noncondensing the year round and throwing out immense volumes of exhaust steam to the atmosphere. As before, the coal bill to run this power house is charged up to necessary operating expenses and no further thought is given to the matter. Nevertheless the traction company is throwing away what, if it could properly be applied, would be worth fifty thousand dollars a year to the green-house man; and the green-house man is annually burning up thousands of tons of the best mine-run coal.

Aside from the merely commercial standpoint, it is the duty and should be the pleasure of every engineer to exert his influence toward the grouping, as far as possible, in his own plant, at least, of the operations that advantageously can be combined to reduce the total energy expenditure.

Law and Smoke

Ever since laws were made the question as to the method of enforcement has always been one upon which there were many divergent opinions. Those intrusted with the work of seeing that the laws are obeyed are being continually criticized by the general public for their leniency. On the other hand, there is even a louder outcry from those who are affected by the laws, these latter often complaining bitterly on account of their literal enforcement.

Take the case of a certain steam plant, modern in every respect, fitted up without regard to expense, with every appliance and convenience which can by any possibility be made to increase the general efficiency. Month after month this plant runs along with no smoke and no fines.

In the next block there is a cheap and comparatively simple plant where just enough attention has been given to the smoke question to come inside the law. This plant smokes every day and every hour of the day, but manages in one way or another to keep inside the legal limit of six minutes' smoking per hour. This plant also runs along with no fines and both are on the same legal footing, although really there is no comparison between them, either in equipment or intent to obey the law. One has to be forced to do the legal minimum, while the other willingly coöperates beyond a reasonable maximum.

Then comes a day when a tube cap springs a leak in the high-class plant, the boiler has to be cut out, and as the load is heavy, another boiler must be fired up. Before the brickwork in the setting of the new boiler can be heated to working temperature, the plant smokes, the law is violated and a fine imposed. In a year's running the smoke that comes daily from the cheap plant contributes largely and without penalty to the general smokiness of the atmosphere, while the other plant, which has smoked once in the same time, purely through an unavoidable accident, has a big black mark against its record.

The smoke question is yet new and this is one of the kinks that has not been smoothed out.

NEW·POWER·HOUSE ·EQUIPMENT·

What the Inventor and the Manufacturer are doing to save time and money in the Engine Room and Power House

Air Excluders for Economizers

The following appeared in *Engineering*, London, relating to the Ogden air excluder for economizers:

"It is an admitted fact that air leakage into the flues reduces the draft, and at the same time lowers the temperature available for heating the water. The object of the patent air excluder, as its name implies, is to provide means for excluding the cold air or draft from entering the interior of an economizer through the chain holes, i.e., the holes through which the chains attached to the scrapers are made to pass and work. Innumerable devices for excluding the cold air or draft from entering the interior of the economizer through the chain holes have been tried, many of them ingenious, but mostly inadequate.

"Such an apparatus is manufactured by Edward Bennis & Co., Limited, Little Hultons, Bolton, and is a simple and efficacious device for fitting over the economizer chain holes. In Fig. 1, *A* is a part sectional front elevation, and *B* a side elevation. A detail is shown in plan at *C*. It consists, as will be seen, of a cross-shaped piece of iron, through which the chain passes at *D*, the piece being long enough to take four links and thus prevent air passing down by the chain."

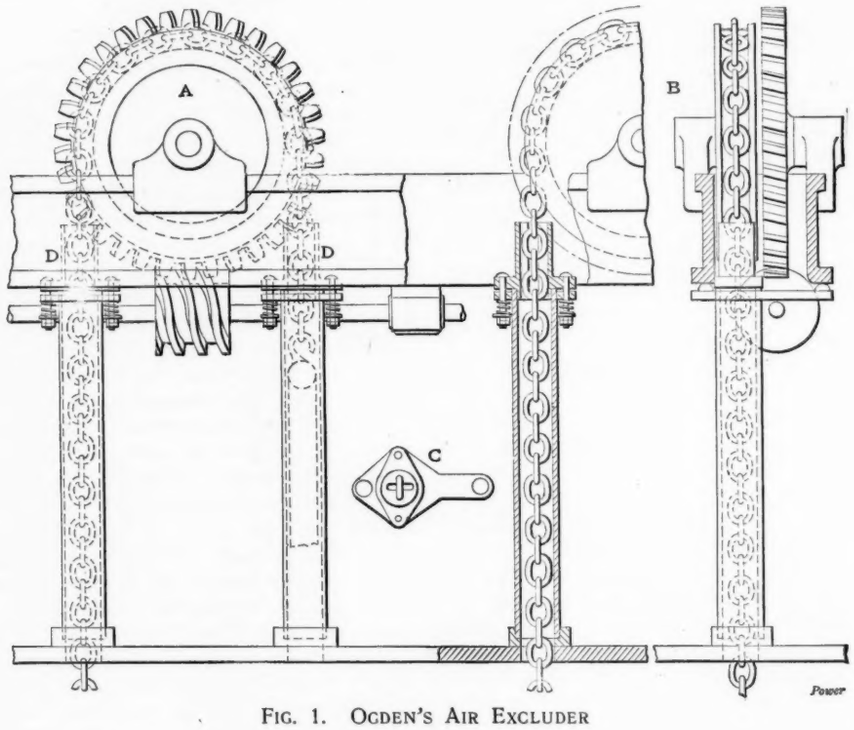


FIG. 1. OGDEN'S AIR EXCLUDER

What appears to be a much superior device for preventing air leakage past the economizer chains is shown in Fig. 2. It is a plug-link air-excluding chain designed by A. H. Blackburn of the American Green Fuel Economizer Company, Matteawan, N. Y.

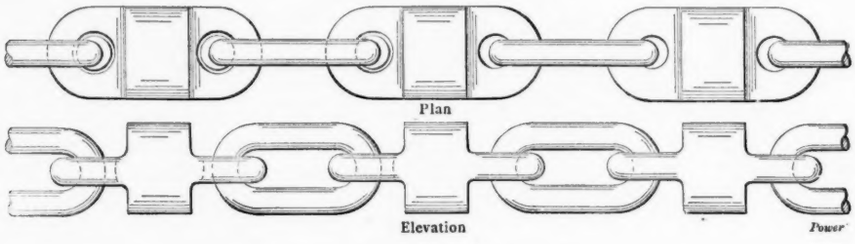


FIG. 2. PLUG-LINK CHAIN

Referring to Fig. 2 it will be seen that every other link forms a plug, the distance between the links being less than the depth of the top headers, so that the openings are effectively closed. This involves no complication of the economizer construction, nor are there any unsightly tubes or pipes sticking up from the headers. As a matter of fact, even this is not required where soft coal is used as the latter forms a heavy coating of soot and tar on the chain, making it look like a smooth rope that just fits the hole.

New Sturtevant Generating Set

The generating set, described herewith, is designed for use in isolated plants, and is the latest product of the B. F. Sturtevant Company, Hyde Park, Mass.

The set consists of a compound direct-current generator of either the six- or eight-pole type, depending upon the size, attached to the same subbase and direct connected to the vertical, single engine, known as "Class VS-7." (See Fig. 2.)

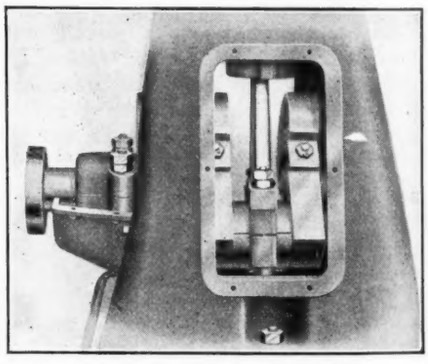


FIG. 1. VIEW OF THE CRANK BOX

The manufacturers claim that in this model they have retained the best, and eliminated the objectionable features of their previous designs, and have also added many other details of construction.

This engine is of the high-speed inclosed type, the reciprocating parts being entirely inclosed within the frame, which is provided with openings through the front, back and sides, to permit ready access for inspection or adjustment. These openings are fitted with dust-proof covers, which may be easily removed. A water-shed partition prevents the oil from the frame being carried into the cylinder, or the water in the cylinder being carried into the frame. This

water-shed partition, together with a piston-rod stuffing box, are located in a distance piece, separating the cylinder from the frame. Access to these parts is readily obtained through openings in the distance piece while the engine is in operation. Fig. 1 shows a view of the crank box.

The gravity lubricating system consists of a reservoir cast in the top of the frame from which the oil flows to the bearings through piping equipped with sight feeds. All the oil not used flows into a reservoir cast in the subbase and after filtering through fine screens is forced to the top reservoir by a pump, located in the subbase and entirely submerged in the oil. The engine may be run independently of the oil pump, by filling the top reservoir, through an opening provided in the frame, and drawing off the excess oil from the bottom reservoir through a drain cock.

A Rites inertia governor is used, so regulating the speed that the variation between no-load and full-load is said to be not more than 1½ per cent.

The generator armature is of the iron-clad, two-circuit, ventilated drum type. The armature coils are form wound and are protected against oil and water. The armature conductors, commutator segments and brushes are proportioned to give low current density, thus insuring low temperature rise and high efficiency. The brush rigging is arranged so that the brushes may be adjusted separately or may be adjusted simultaneously by revolving the brush ring.

The magnet frame is of cast iron and is divided on a horizontal plane. The pole pieces are of wrought iron and together with cast-iron shoes are through bolted to the frame. The fields are machine wound and of open construction to secure maximum radiation and ventilation.

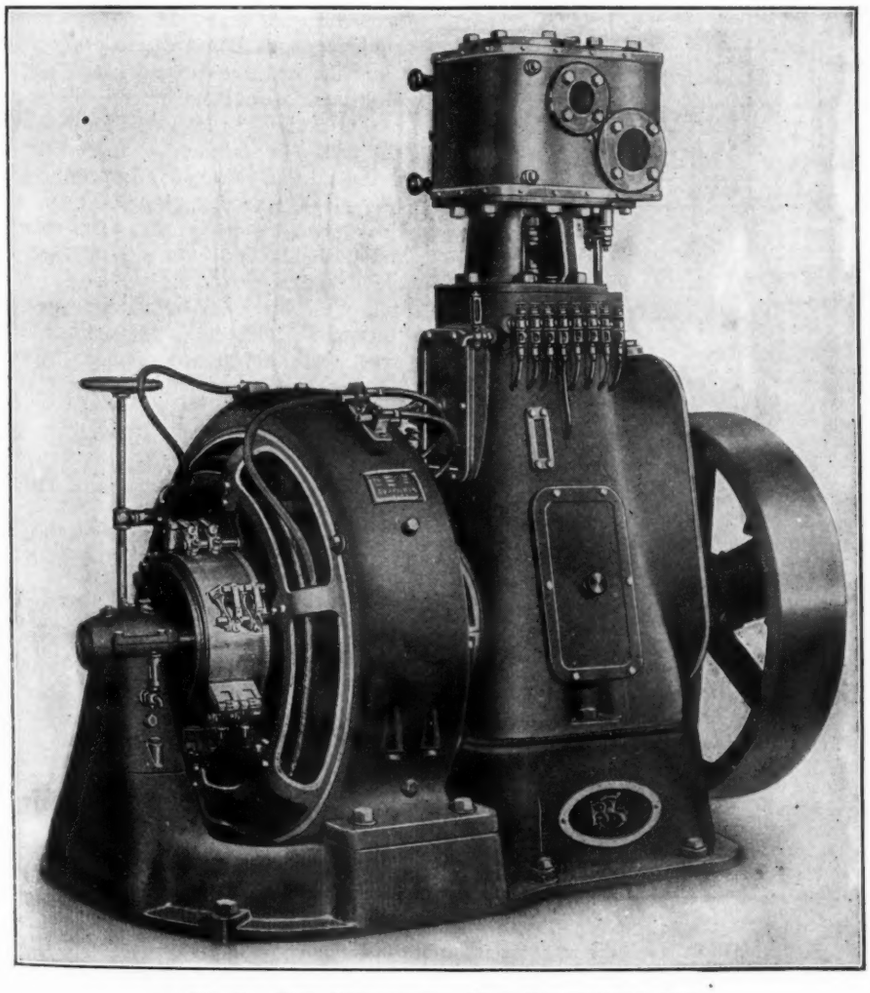
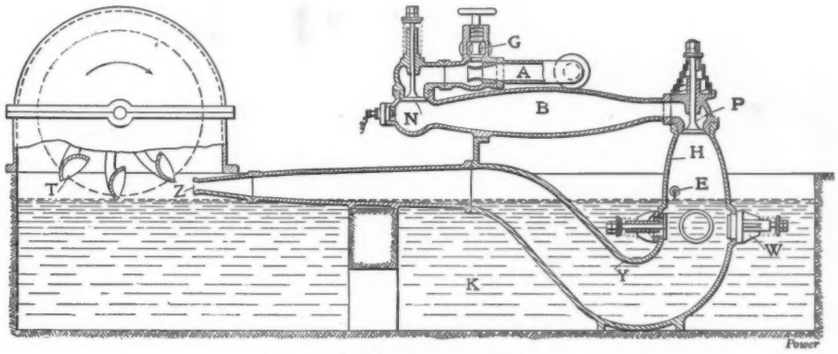


FIG. 2. THE STURTEVANT NEW GENERATING SET

Butler's Hydro-gas Engine

On another page will be found an article dealing with the Humphrey internal-combustion pump. This is the first time attention has been directed to the possibilities of using the explosive force of gas to produce power other than by a piston.

In a recent issue of *The Mechanical Engineer*, the following appeared regarding a hydro-gas engine.



BUTLER'S HYDRO-GAS ENGINE

The problem of applying gas power in a more direct manner than can be obtained in a piston engine has engaged the attention of a number of inventors, some of the very earliest attempts to obtain power from explosive mixtures taking the form of a pistonless engine. An engine of this class was suggested by E. Butler, M.I.M.E., in the discussion on Nielson's paper before the Institution of Mechanical Engineers, in 1904, and a sectional elevation of an actual design worked out by himself is illustrated herewith. This engine which may be termed a hydro-gas turbine, causes an intermittent jet of water to be forced against the wheel of a turbine at high velocity.

Referring to the figure, *Y* is a submerged siphon-shaped explosion chamber, provided with a series of filling valves *W* arranged in a belt below the water level. Above the filling valves the chamber is continued upward to form a combustion chamber, explosive mixture to which is supplied at a pressure of from 80 to 100 pounds per square inch from a primary explosion chamber *B*, past an intercepting valve *P*, this explosion having the effect of causing a secondary explosion effect, at greater pressure, to take place in the chamber *H*, and by this means to expel water contained in the siphon chamber *Y* in the form of a jet at *Z*, against a turbine wheel *T*.

Immediately following the expulsion of the water, the burnt gases resulting from the primary and secondary explosions will be free to escape. Succeeding charges of air and gas from *A* and *G* are automatically drawn into the primary explosion chamber *B*, past an ordinary admission valve *N*, by reason of the

vacuum effect produced in the siphon chamber from the expulsion of its charge of water. Immediately following the release of pressure in *Y*, water again enters through the filling valves *W* to the level of the contents of the tank or cistern *K*, which is maintained at constant level by a float or overflow to make up for loss by leakage or evaporation.

Ignition of the charge in the primary chamber is timed automatically by the water in the siphon chamber, on its contacting with the battery-circuit terminal *E*, this taking place at the completion of the water instroke. The effect of the ignition at the end of an elongated chamber as shown at *B* is to drive a portion of its contents, before combustion is complete, past an intercepting valve as at *P*, into a secondary explosion chamber, as at *H;* mixture can be, by this means, forced into the space over the water at a pressure, depending on the force of the explosion in *B*, and to the proportions of the two chambers.

The mixture thus automatically compressed is ignited by the burning gases from *B* entering at the tail end of the transference of the charge from *B* to *H*, and as commonly obtained in the starting of heavy gas and oil engines on this principle, frequently attains to pressures of from 250 to 350 pounds per square inch. The action of the issuing jet is obviously intermittent, the number of strokes per minute being determined in an engine of a given size by the area of the nozzle and supply valves.

In regard to power, it is estimated that an engine built on these lines and having a siphon chamber 12 inches in diameter would be capable of developing some 100 to 150 indicated horsepower at 20 strokes per minute, on city gas or petrol; but good as this is, there is a limit to its usefulness if depending on ignition of mixture which is uncompressed, as on this account it would be probably unsuitable for producer gas. However, the engine possesses features of novelty, and for some applications may have useful and interesting possibilities.

Improved Feed Water Purifier

The improved thermal water purifier and softener manufactured by the Steam Appliance Manufacturing Company, Batavia, N. Y., is illustrated herewith. It is a device to furnish a steady flow of soft, clean, water from which the scale-forming matter and other objectionable substances have been eliminated.

The water under treatment is taken preferably from an exhaust heater at as high a temperature as it is possible to obtain, and still further heated by means of live steam, to a temperature in excess of 300 degrees Fahrenheit, in a tubular heater. This heater is very simple in construction, the heating surfaces being brass tubes of large diameter, and which, it is claimed, do not scale.

At the high temperature attained the scale-making salts become insoluble in the water and the corrosive salts are decomposed into insoluble noncorrosive compounds, which the water carries in suspension to the filter. Should oil be present in the water under treatment it is absorbed by the precipitated salts and retained on the filter bed.

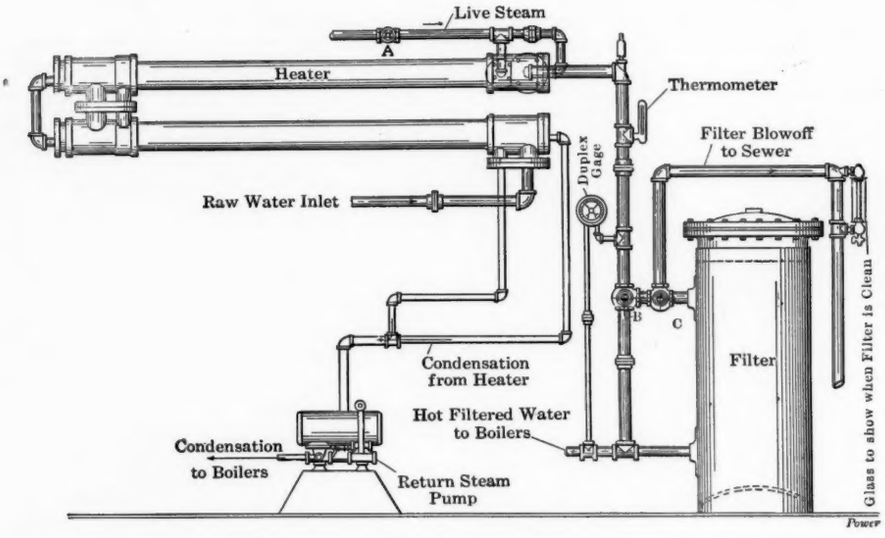
In passing through the filter bed of emery, the water deposits its suspended impurities and passes in its hightly heated condition to the boilers.

When the filter bed becomes foul from deposited matter it is cleaned by closing the steam valve *A* to the heater and manipulating the cocks *B* and *C* so as to reverse the flow of water through the filter bed and carry the deposited impurities out through the blowoff pipe.

The condition of the filter bed is indicated at all times by the duplex gage and when washing the completeness of the cleansing is shown by the glass telltale.

The steam condensed in the heater coils is returned to the boiler by a float-controlled steam pump.

With this apparatus, it is claimed that the user is certain to have boilers in the best condition, at all times, without the use of chemicals, with a minimum of attention and no charge for maintenance or repairs, and that he is often enabled to use a supply of water which being oily, muddy or hard, has previously given poor results in the boilers.



FEED-WATER PURIFIER AND CONNECTIONS

Flexible Packing Screws

This is a packing tool consisting of a helical spring having a block engaged in one end, provided with a socket for the reception of a bit, this block being equipped with a set screw to hold the bit in the socket. A chain (see Fig. 1) is attached at one end of the block and passes through the spring. In the opposite end of the spring is engaged the reduced portion of a block having a longitudinal passage receiving the stem of a hook engaging the chain. The stem of the hook extends outwardly beyond the block and is threaded for the reception of a nut which may be operated to draw the stem of the hook through the passage, thus varying the distance between the two blocks and adjusting the tension of the spring.

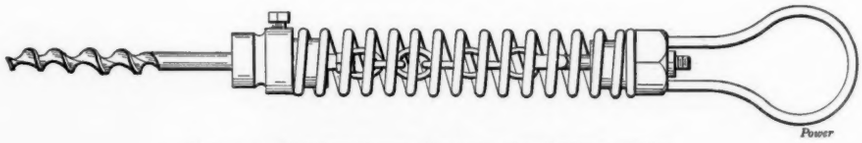


FIG. 1. COMBINATION CHAIN AND SPRING TYPE

A handle yoke has its ends secured in the block, at opposite sides of the opening of the passage, and this handle yoke may be grasped for operating the packing tool.

In some cases, when old or hard packing has to be removed from a stuffing box, the operator may find it necessary to pull upon the handle with block and tackle, and in this case, the chain takes the extra strain and prevents undue distortion of the spring.

Fig. 2 shows another type of packing screw made similar to that shown in Fig. 1, with the exception of the chain.

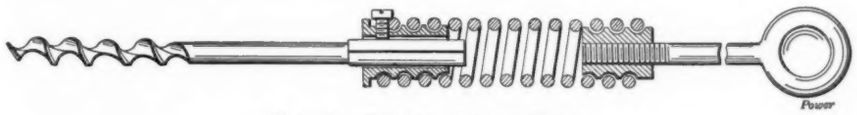


FIG. 2. SIMPLE SPRING TYPE

This device is handled by the Investors and Inventors Corporation, 1114 Chestnut street, Philadelphia, Penn.

Sheet Packing

In spite of the advantages of "Goetze" copper and metal gaskets, there are those who wish to cut their own packings from the sheet, or who for some reason do not want a metal or shaped gasket. For such, "Goetzerit," a sheet packing, has been perfected.

It is made in both red and white, from asbestos fiber, compressed under an exceedingly high pressure, and impregnated with a substance which, it is claimed, makes it absolutely proof against the action of superheated and saturated steam. "Goetzerit" white packing, Fig. 1, is especially recommended for oils, benzine, petroleum acids, ammonia, gas, alkaline products, etc. It does not squeeze out and narrow the inside diameter of the piping, and cannot be blown out, it is said, even at the high steam pressure now in use.

"Goetzerit" red packing, Fig. 2, is made in any desired thickness in sheets 39 inches square. The white is made in seets 45 inches square.

Ready-made "Goetzerit" gaskets for standard and extra heavy flanged fittings of from 1 to 24 inches are also made.

Another kind of packing is known as "Ideal" high-pressure packing. It is equally excellent for saturated and superheated steam, for hot and cold water. It is impregnated by an infusible fat which stands against heat and is said to have practically inexhaustible lubricating ability. It is prepared for all kinds of stuffing boxes and is manufactured in sizes from ¼ to 2 inches square.

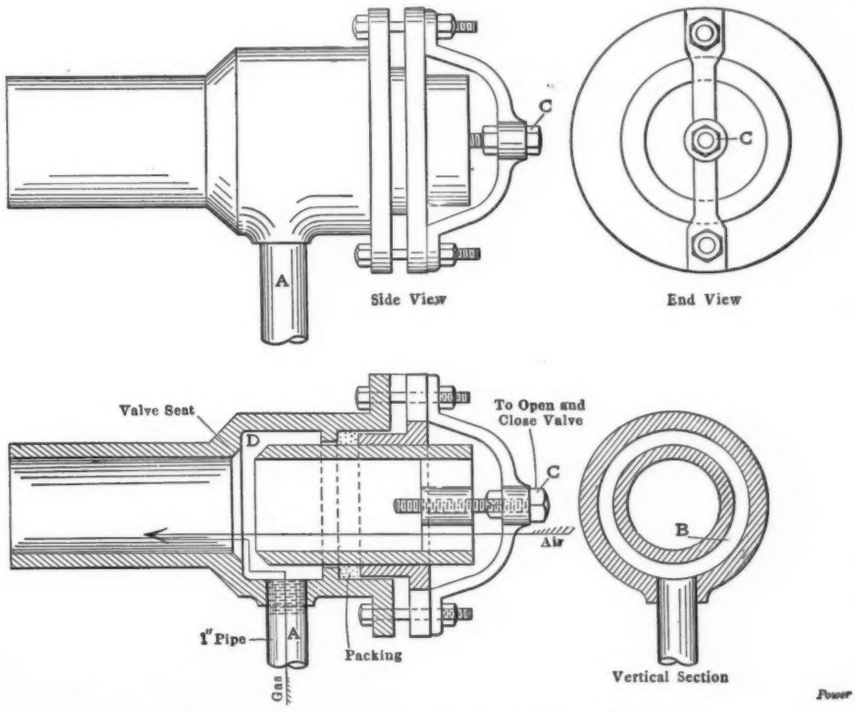
These packings are manufactured by the American Goetze-Gasket & Packing Company, New Brunswick, N. J.

Harkahn Gas Burner

In this gas burner the gas enters through inlet pipe *A* and is admitted to the mixing chamber through a circular opening *B* which extends around the entire inside circumference of the burner. This opening acts as a valve, being operated by screw *C*, and can be entirely closed or opened any desired amount.

Immediately outside of the circular opening, and at the end of the inlet pipe, is a circular reservoir *D*, for the purpose of providing a reserve body of gas to draw from, which insures a steady flow of gas through the circular opening into the mixing chamber.

This burner is manufactured by the Harkahn Burner Company, 3721 Boquet street, Pittsburg, Penn.



EXTERNAL AND SECTIONAL VIEW OF GAS BURNER

The Vulcan Soot Cleaner

The Vulcan soot cleaner is a device designed to prevent the formation and accumulation of soot on the heating surfaces of water-tube boilers. It consists of an arrangement of stationary piping connected to the steam main and installed on the side of the boiler. It has twelve or more vertical branches, with an operating valve for each, and perforated pipe extensions reaching between the tubes the entire width of the boiler. These extensions are so located and perforated as to direct steam jets at every part of the heating surface with effective force. Short three-way nozzles embedded in the brickwork complete the system, reaching the points of extreme temperature.

In the accompanying illustration the system is shown as applied to a Sterling boiler. It is operated by opening and closing the valves in succession, blowing with the draft, the entire operation requiring not more than six minutes, and interfering in no way with the regular operation of the boiler. The ease and

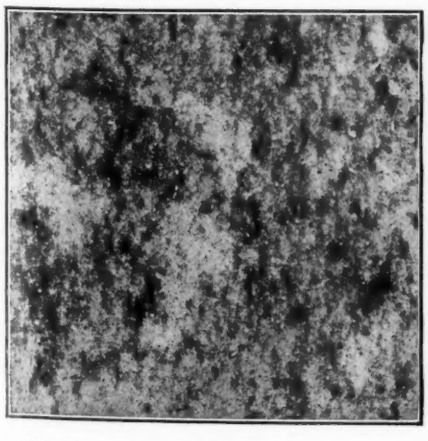


FIG. 1. WHITE "GOETZERIT" SHEET PACKING

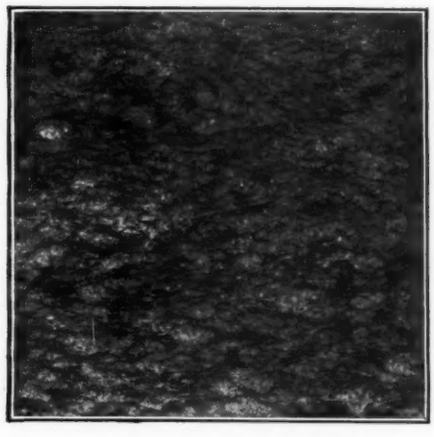
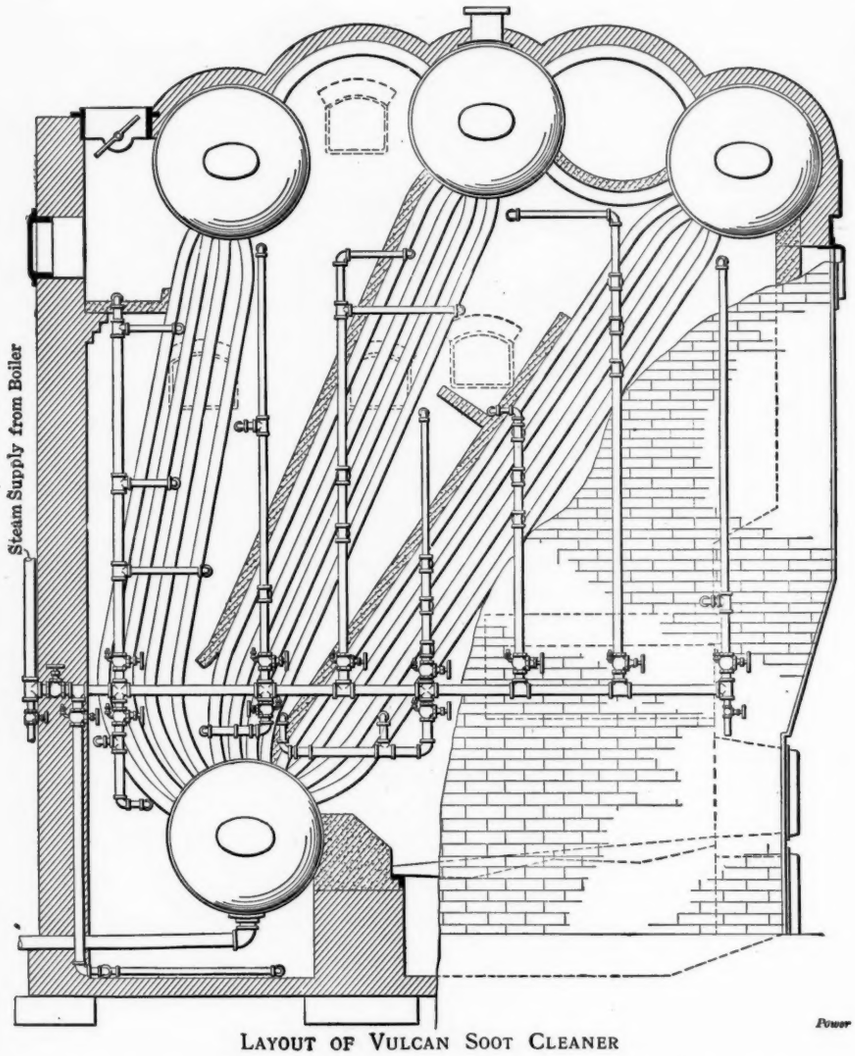


FIG. 2. RED "GOETZERIT" SHEET PACKING



LAYOUT OF VULCAN SOOT CLEANER

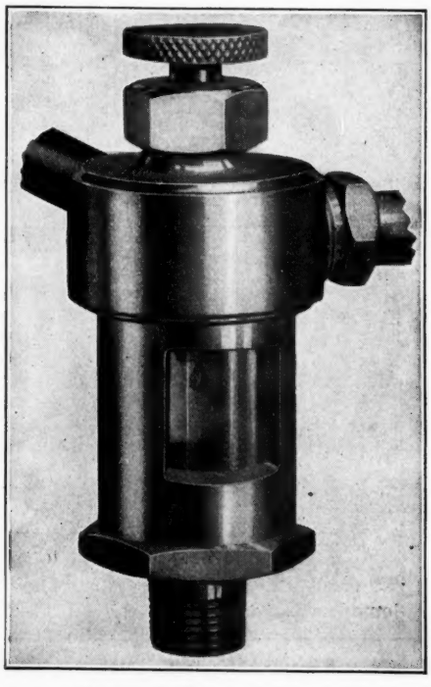
rapidity of this cleaner insure its frequent operation, whereas the dirt, labor and expense of the inefficient hand process make even attempts uncertain. The installation of this system makes possible and profitable the sealing of the side blow doors, which in the ordinary setting are a source of considerable loss.

The system is made by the Vulcan Soot Cleaner Company, Du Bois, Penn., and G. L. Simonds & Co., Monadnock building, Chicago, Ill., are exclusive western agents.

Richardson Oiling System Sight Feed

A new device gotten out by the Sight Feed Oil Pump Company, Milwaukee, Wis., is shown in the accompanying illustration. It is an adjustable sight-feed fitting, for use in connection with any gravity-fed bearing-lubrication system where it is desirable to see the oil flow at the points lubricated. The fittings are made for one, two, three or four pipe connections.

The valve stem by which the oil feed is regulated, is tightly packed against pressure, and the sight-feed glasses are set up tight on shellacked cork washers. These glasses, by reason of the shape of the body, are exceptionally well protected against injury. The cast-iron bodies are nickel plated, thus presenting a neat appearance.



RICHARDSON'S SIGHT FEED

Hewitt Lectures at Cooper Union

Every Monday night at 8:15 p.m., from February 7 to March 28, Charles E. Lucke, professor of mechanical engineering in Columbia University, is scheduled to deliver lectures on "Power" in Cooper Union hall. The series is known as the Hewitt lectures, of which a brief synopsis follows:

February 7: The part played by mechanical power and machinery in supplying daily wants, the magnitude of important industries dependent on power, natural sources of energy and the principal systems of changing it to useful forms and the importance of conservation.

February 14: The development of power systems and some of the more important natural laws and physical processes applied in power systems for transforming natural forms of energy into useful work.

February 21: Essential elements of steam-power systems and the processes carried out by the mechanism for the conversion of fuel into useful work.

February 28: Principles of reduction of waste in steam-power systems and apparatus designed for waste reduction.

March 7: Essential elements of gas-engine mechanisms and their respective duties, economy of fuel, extent of heat wastes and the limits of the system.

March 14: Fuels for gas engines, gas producers, carbureters and vaporizers for gasolene, oil and alcohol; relative economy of steam and gas plants.

March 21: Water-power systems, electrical apparatus for transmission of power, other systems of transmission by compressed air, hydraulic and gas piping; economic positions of water power to fuel-burning systems.

March 28: Social and economic consequences of the substitution of power and machinery for hand labor.

The lectures will be illustrated with stereopticon views and are open to the public, no tickets of admission being required.

A demonstration of CO_2 recording and other boiler apparatus will be made at the Franklin Union, Boston, Mass., on Tuesday evening, February 8, under the auspices of the *New England Engineer*. Edwin A. Uehling will explain his recorder, and Lewis Sanders, of the Sarco Company, the machine which is handled by that company. Three boilers are located directly under the stage, and these and other instruments are to be connected and operated on the stage in view of the audience, while an efficiency test is conducted by expert engineers in the boiler room.

INQUIRIES OF GENERAL INTEREST

Questions are not answered unless they are accompanied by the name and address of the inquirer

Foot-pounds and Energy

What is the meaning of the term foot-pounds as applied to prime movers? Does the same rule apply to calculating the energy or striking force of bullets? Does the element of time enter into the calculation of the energy or striking force of bullets when fired from a rifle? Does the element of time enter into the calculation of the energy of any or all moving bodies?

J. D. T.

The foot-pound is the unit of energy and means the equivalent of a force of one pound acting through a distance of one foot. For example, to raise 10 pounds one foot, Fig. 1, requires the exertion of a force of 10 pounds through one foot and the expenditure of

$$10 \times 1 = 10$$

foot-pounds of energy. In Fig. 2, 100 pounds is raised 5 feet, requiring the expenditure of

$$5 \times 100 = 500$$

foot-pounds of energy, which in this case is developed by the exercise of a pull of 50 pounds through a distance of 10 feet. The fact that the load is supported by two ropes divides the stress so that each rope is under a tension of but 50 pounds; but the free end has to move 2 feet, and take up a foot of each of the supporting ropes to raise the load a foot (the friction of the tackle is not taken into account). In Fig. 3 it takes a pull of 150 pounds to move the load along, and 150 foot-pounds of energy is expended upon it for every foot that it is moved.

If the force applied is just enough to overcome the frictional resistance, the body, after it is once gotten into motion, moves along at a uniform velocity. If the force is greater than the frictional resistance the velocity of the body is accelerated. A force of one pound acting upon a body weighing one pound will increase its velocity at the rate of something over 32 feet per second. It is difficult to place an exact value upon this quantity, so let us follow the common usage and call it g.

The force necessary to get a body into motion at a given velocity is

$$Force = \frac{Weight \times acceleration \times time}{Time \times g}.$$

Or, since the velocity of a body at the end of a given time is the acceleration per second multiplied by the time in seconds, and

$$Velocity = Acceleration \times time,$$

$$Force = \frac{Weight \times velocity}{Time \times g}.$$

The space moved through by a body is the product of its average velocity in feet per second and the number of seconds that it is in motion at the average velocity.

The final velocity of a body starting from rest is the product of the acceleration or increase in velocity in feet per second and the number of seconds that acceleration has continued. If the initial velocity is zero and the acceleration is uniform the average velocity will be one-half the final velocity, so that the space moved through by a body in acquiring a given velocity is

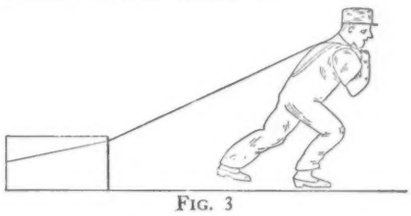


FIG. 3

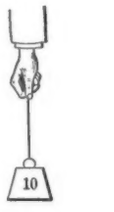


FIG. 1

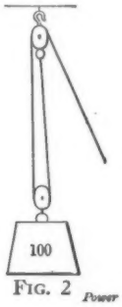


FIG. 2

$$Space = \frac{Velocity \times time}{2}.$$

Since energy is the product of force and space,

$$Energy = \frac{Weight \times velocity}{Time \times g} \times \frac{velocity \times time}{2};$$

$$Energy = \frac{Weight \times velocity^2}{2g}.$$

When a moving body is brought to rest it must give up the energy stored in it, which is equal to the amount expended in getting it into motion. The force which it will exert by impact, or the retarding force exerted to bring it to rest, must be such that its product when multiplied by the space through which the body moves while being brought to rest, will equal the energy in the body. The element of time enters into the calculation only as a factor of this space. If, for example, we want to know what force must be applied to bring a body moving at a given velocity to rest in a given time, we can calculate that the body would move through

$$\frac{Velocity \times time}{2} = Feet\ of\ space,$$

and the energy divided by this space factor would give the force

$$F = \frac{W v^2}{2g} \div \frac{v t}{2} =$$

$$\frac{W v^2}{2g} \times \frac{2}{v t} = \frac{W v}{g t}.$$

Horsepower Constant

How is the horsepower constant of an engine found?

J. B. A.

A horsepower constant is that number which, multiplied by the mean effective pressure in the cylinder of an engine, will give the horsepower that the engine is developing. It is found by multiplying the area of the piston by its speed in feet per minute and dividing the result by 33,000. This quotient is the horsepower constant of that engine. For instance, suppose you had an engine, 14x42-inch, running 86½ revolutions per minute, the area of the piston is 153.9 square inches; the piston rod is $3\frac{3}{16}$ inches in diameter having an area of 7.9 square inches; subtracting one-half of this area or 3.9 square inches from the area of the piston leaves 150 square inches for the effective area of the piston on each side. As the engine makes 86½ revolutions per minute, the piston speed is 605.5 feet per minute; multiplying this speed by 150, you have 90,825 as the number of foot-pounds developed per minute by the engine for each pound mean effective pressure; dividing this by 33,000, the number of foot-pounds per minute in a horsepower, the result is 2.75 horsepower for one pound mean effective pressure. If the mean effective pressure should happen to be 40 pounds, the horsepower of the engine would be

$$40 \times 2.75 = 110\ horsepower.$$

Consul Frederick I. Bright, of Huddersfield, Eng., quotes a British newspaper statement that an Italian engineer has invented a reversible turbine engine. The advantages claimed for the engine are that "there are no blades or vanes to break or get out of order;" that "it will work with equal power or speed in both directions, forward or reverse," and that "it can be built in all sizes from five horsepower to 50,000 horsepower." It is reported a large company is to be formed.

NEW PUBLICATIONS

"Fuel Tests with House-Heating Boilers," by J. M. Snodgrass, is issued by the Engineering Experiment Station of the University of Illinois as Bulletin No. 31. This bulletin is designed for the technical rather than for the general reader. It will be of interest to producers of fuel for domestic heating and to those who are concerned with the design and method of house-heating apparatus. Comparatively few tests have hitherto been made in connection with house-heating apparatus, and the results of this bulletin constitute a timely definition of its efficiency. The fuel used included anthracite coal, Pocahontas coal, and various grades of Illinois bituminous coal. The relative advantages to be derived from the use of these several fuels in house-heating apparatus are discussed and their relative value is defined. It appears that Illinois coal, while less efficient than others tested, supplies through its low cost the least expensive means of heating. The conclusion that the use of Illinois coals in such service must continue to increase is apparent. By the careful preparation of such fuel, the dirt, soot and smoke resulting from its use may be materially reduced. The bulletin is intended to constitute the first of a series dealing with fuels and apparatus used for house-heating or other domestic purposes. Copies may be obtained gratis upon application to W. F. M. Goss, director of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

A jet condenser giving a vacuum of 28.75 inches of mercury which is so designed that a thorough mixture of exhaust steam and cooling water takes place and at the same time the air present is prevented from pocketing and is delivered to the air pump at a minimum temperature, involves numerous interesting departures in condenser design. These features are brought out, and the general theory of jet-condenser construction discussed in a reprint of the article, "A Radical Improvement in Jet Condensers." This booklet is being distributed by the Wheeler Condenser and Engineering Company, of Carteret, N. J.

A pamphlet entitled, "Arrangement of Engine Cylinders to Produce Uniform Torque" has just been issued by the American Engine Company, of Bound Brook, N. J. This pamphlet contains typical indicator cards taken from the American ball angle-compound engine, and also a derived crank-effort diagram. This diagram shows that this type of engine produces a torque which is nearly as uniform as that given by steam turbines, while the steam consumption is considerably less than that of turbines. The booklet also contains a discussion of the crank-effort diagram and will be sent free upon application.

BOOKS RECEIVED

"The Design and Construction of Internal-Combustion Engines." By Hugo Guldner and H. Diederichs. D. Van Nostrand Company, New York. Cloth; 672 pages, 8x11 inches; 728 illustrations; 36 folding plates; tables; indexed. Price, $10.

OBITUARY

Lercy M. Harvey

Many friends were greatly grieved on Wednesday, January 19, to learn of the death of Lercy M. Harvey, sales manager of the Milwaukee district office of Allis-Chalmers Company. Mr. Harvey had been in poor health for the past five months and a short time ago went to Augusta, Ga., with the hope that the change in climate would benefit him. He died at the New Partridge hotel in that city early on Wednesday morning from diabetes and brights disease.

Mr. Harvey was born in Oak Park, Ill., about thirty-seven years ago. His early education was obtained in the public schools of that suburb. After completing his preparatory work he entered the University of Michigan, graduating in 1898 from the course in electrical engineering.

After graduation Mr. Harvey entered the employ of the Westinghouse Electric Company and was with that company for about a year. From there he took up experimental work for the Siemens & Halske Company, in Chicago. Later he was in the Chicago sales office of the Northern Electric Manufacturing Company. Six years ago he accepted a position in the sales department of Allis-Chalmers Company and about three years ago was made manager of the Milwaukee district office, which position he held until his death.

Mr. Harvey was a member of the Milwaukee Club and the Milwaukee Country Club.

In November, 1903, Mr. Harvey was united in marriage to Miss Julia Stuart and for the past several years they have made their home at 625 Fredrick avenue, Milwaukee. Besides his wife, Mr. Harvey is survived by his father and mother.

Boiler Explosion at Midvale, O.

On December 17 a boiler exploded with disastrous results at the plant of the Robinson Clay Products Company, Midvale, O. Two firemen were instantly killed, the body of one being blown a distance of about 800 feet. The total property loss amounted to approximately $20,000. Further particulars will be given in an early issue.

Banquet of Engineers at Boston

Under the auspices of the local members of the American Society of Mechanical Engineers, a banquet was tendered Friday evening, January 21, at the Hotel Somerset, in Boston, to George Westinghouse, the newly elected president of the American Society of Mechanical Engineers, J. A. Bensel, president of the American Society of Civil Engineers, Lewis Butler Stilwell, president of the American Institute of Electrical Engineers, and George B. Francis, president of the Boston Society of Civil Engineers, and other distinguished guests. Over four hundred invitations had been accepted and practically this number of engineers were gathered about the tables in the banquet hall of the Hotel Somerset, when Prof. Ira N. Hollis, who acted as toastmaster, called the assembly to order. He said that New England was a remote corner of the country, but a great center for engineering, and the home of the oldest engineering society in the country, the parent of all American engineering societies, the president of which, George B. Francis, was introduced to welcome the guests, not only in behalf of the Boston Society of Civil Engineers, but of the engineers of Boston and vicinity.

Mr. Francis, after extending such a welcome, took advantage of the coming together of so many local engineers to urge the erection of an engineering societies' building in Boston, similar to the one in New York. The suggestion met with an enthusiastic reception, and later in the evening a formal vote was taken to the effect that the councils of the various local societies be requested to appoint representatives to a joint committee to consider ways and means for carrying out the project.

In introducing J. A. Bensel, president of the American Society of Civil Engineers, Professor Hollis said that engineering is the oldest of the professions. The schools of civil engineering are older than the oldest living graduate, and the American Society of Civil Engineers has been recruited largely from the graduates of these schools. He then presented Mr. Bensel as president of the second oldest engineering society in America, one who has served the city of New York in large capacities and which is now engaged in bringing water to the city from the Catskill mountains. Mr. Bensel spoke briefly and pleasantly and jollied the Boston engineers by referring to their city as one where the passage of time was marked by a growth of the weeds upon the Commonwealth pier.

The next speaker, L. B. Stillwell, president of the American Institute of Electrical Engineers, was introduced as the representative of the youngest of the profession. The Hon. Charles Francis Adams said that as we got along in life

BANQUET ROOM AT THE HOTEL SOMERSET, BOSTON

we became more and more conscious of our own limitations. He described himself as the dog upon whom Mr. Westinghouse had tried some of his ideas before promulgating them, said that he had become conscious of the fact that he had his limitations even as a dog.

Professor Hollis in introducing George Westinghouse said that he had served in the army during the Civil War, heard the firing of the guns at Gettysburg, had been a cavalry officer—corporal, corrected Mr. Westinghouse—and afterward an officer in the engineering corps of the navy, where his engineering career began. At an age when most young men are coming out of college he invented the air brake. He is "only" an honorary member of the Mechanical Engineers and one of the two living honorary members of the American Association for the Advancement of Science.

Mr. Westinghouse deprecated the present tendency toward Government control of public service corporations and enlarged upon the disastrous results of unrestricted competition. The magnitude of industrial and public service developments and the evil practices in connection with their development and operation so frequently disclosed in the law courts and press have so aroused the public that there is now a fixed determination to establish by National and State laws an exacting Governmental control of practically all forms of corporations in order that competition may be encouraged and not stifled, but seemingly without due regard to the real objects in view; that is, the securing of the best public service in all forms; the best foods and goods for our daily needs; the greatest possible comfort to the masses, and as great freedom as possible from those restrictions which hinder rather than promote honest endeavors.

Many of the hardships which will arise in the daily conduct of our affairs as the result of existing and proposed legislation might have been avoided by those responsible for the creation of great combinations had they appreciated the inevitable consequences of their selfish and unwise course in their efforts to gain a monopoly by suppressing competition by methods so transparently wrong that those efforts have been met by the strongest possible demand for controlling legislation.

I have said the tendencies have of late years been toward large combinations, but fortunately there are indications, of which this gathering is one of many, that the great leaders in our affairs, as witness the meetings now being held in Washington of governors of numerous States, are alive to the importance of the regulation of legislation and the creation of sentiments which will bring business men to their senses.

By a combined effort of all of the engineering societies, with the financial support of all manufacturers who would be largely benefited, and who could well afford to pay in pro rata amounts the expense of a well equipped and officered bureau of standardization, it seems to me such a bureau could be established and could work a reform of incalculable value in our present practice, and thus forestall Governmental activity in the same direction.

The public needs no further incitement to the regulation of such matters by the Government. What is needed is such wise coöperation on the part of the large interests involved and such fair consideration of the public rights as may stay further Governmental action and finally render it unnecessary.

Other speakers were Prof. D. C. Jackson, chairman of the Boston section of the American Society of Electrical Engineers, R. Clipston Sturgiss, president of the Boston Society of Architects, E. L. Clark, of the Boston Chamber of Commerce, and Irving E. Moultrop, of the Boston Edison Company.

The audience was also favored with a description of the machinery of the battleship "North Dakota," illustrated with lantern slides by Charles B. Edwards, of the Fore River Shipbuilding Company.

Marine Engineers Hold Annual Convention at Washington

The thirty-fifth annual convention of the National Marine Engineers' Beneficial Association was held at Washington, D. C., during the week beginning January 17, with headquarters at the Ebbitt hotel. The attendance of delegates numbered about 100. The reports showed the organization to be in a sound financial condition. At the several business sessions of the convention many important measures were passed pertaining to the welfare of the organization.

The National Marine Engineers Supplymen's Association, also in session at the Ebbitt hotel, entertained the delegates and guests during the week with trolley rides, theater parties, etc.

The leading social feature was a smoker held in the ballroom of the New Willard hotel on Thursday evening, at which there was an attendance of about 500, including many Government officials. In every particular the entertainment was first-class and heartily appreciated, the entire company journeying from New York City especially for this occasion. On Saturday morning a reception to the delegates and guests was held by President Taft, who congratulated the members of the association upon the prominent place they occupied in the engineering world. The President shook hands with each visitor.

On Thursday, the following national officers were elected: William F. Yates, president; Art Hyde, first vice-president; William P. Tindall, second vice-president; Charles N. Vosburg, third vice-president; George A. Grubb, secretary; Albert L. Jones, treasurer; Frank J. Houghton, William L. Bridges, John A. Watts, advisory board; Joseph G. Myers, trustee.

The election of officers of the supplymens' association resulted as follows: John W. Armour, president; Joseph F. Hammill, vice-president; J. Inglis Leslie, secretary-treasurer.

The next annual meeting will be held in St. Louis, Mo., during the week of January 16 to 21, 1911.

SOCIETY NOTES

The American Institute of Electrical Engineers has postponed the meeting at Charlotte, N. C., to the three days beginning with March 30.

The fifteenth annual entertainment and ball of the Eccentric Association of Firemen, Local No. 56, I. B. of S. F., of New York, was held at Grand Central Palace, on Saturday evening, January 22. The large hall, which was filled to its capacity, was very prettily decorated with evergreens, ferns and floral designs. An enjoyable vaudeville performance preceded a long dancing program, and good-by's were said in the wee small hours after a most pleasant occasion. This social event always attracts many persons prominent in the field, and there was present a number of distinguished guests. Gavin Hamilton, an esteemed member of the Marine Engineers' Beneficial Association, of the port of New York, and chief engineer of the Department of Charities, was called to the stage during an intermission in the entertainment, and was presented a handsome silver service in recognition of his many acts of courtesy to the firemen's organization.

PERSONAL

Frank Barry, formerly New York manager of the Chapman Valve Manufacturing Company, of Indian Orchard, Mass., has recently been transferred to the management of the western territory of the company, with headquarters at 120-122 Franklin street, Chicago. The products of the Chapman Valve Manufacturing Company are so well and favorably known in the territory of which Chicago is the head that it is only fair to predict that under the management of Mr. Barry the western business will be materially increased.

The man in the explosion is one, at least, who started at the bottom and went up.